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ANNUAL REPORT

OF THE

OHIO ACADEMY OF SCIENCE

Forty-sixth Meeting

1936

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PUBLICATION COMMITTEE

E. L. RICE, *Chairman* C. G. SHATZER R. V. BANGHAM

THE OHIO ACADEMY OF SCIENCE

Organized 1891 Incorporated 1892
Affiliated with the American Association for the Advancement of Science

OFFICERS AND COMMITTEES FOR 1936–1937

President

CHARLES A. DOAN

Vice-Presidents

A. *Zoology:* A. W. LINDSEY
B. *Botany:* CLAUDE E. O'NEAL
C. *Geology:* FRED FOREMAN
D. *Medical Sciences:* R. A. KNOUFF
E. *Psychology:* GARRY C. MYERS
F. *Physics and Astronomy:* G. E. OWEN
G. *Geography:* REUEL B. FROST
H. *Chemistry:* C. E. BOORD
(Vice A. P. MATHEWS, declined)

Secretary

WILLIAM H. ALEXANDER

Treasurer

A. E. WALLER

Executive Committee

Ex-Officio: CHARLES A. DOAN, WM. H. ALEXANDER, A. E. WALLER
Elective: WALTER H. BUCHER, H. H. M. BOWMAN

Board of Trustees

HERBERT OSBORN, *Chairman*, term expires.....1938
GEORGE D. HUBBARD, term expires.....1937
WILLIAM LLOYD EVANS, term expires.....1939

Committee on Publications

EDWARD L. RICE, *Chairman*, term expires.....1937
C. G. SHATZER, term expires.....1937
R. V. BANGHAM, term expires.....1937

Library Committee

MRS. ETHEL M. MILLER, *Chairman*,
In charge of Academy Exchanges and Publications
L. B. WALTON, term expires.....1937
F. O. GROVE, term expires.....1938
W. H. SHIDELER, term expires.....1939

Committee on State Parks and Conservation

EDWARD S. THOMAS, *Chairman*, term expires.....1937
HERBERT OSBORN, term expires.....1937
WILBER E. STOUT, term expires.....1937
G. W. CONREY, term expires.....1938
E. L. WICKLIFF, term expires.....1938
ARTHUR T. EVANS, term expires.....1938
EMERY R. HAYHURST, term expires.....1939
EDMUND SECREST, term expires.....1939
L. E. HICKS, term expires.....1939

Academy Representatives on the Joint Administrative Board, Ohio Journal of Science

EDWARD L. RICE, term expires.....1937
C. G. SHATZER, term expires.....1938

Nominating Committee for 1937

A. DAVID F. MILLER
B. GLENN W. BLAYDES
C. GRACE ANN STEWART
D. CHARLES A. DOAN
E. JAMES R. PATRICK
F. CHARLES W. JARVIS
G. GUY-HAROLD SMITH
H. K. G. A. BUSCH

REPORT OF THE FORTY-SIXTH ANNUAL MEETING OF THE OHIO ACADEMY OF SCIENCE

WILLIAM H. ALEXANDER,
Secretary

Introductory

One hundred and seventy-three members registered at the Forty-sixth Annual Meeting of the Ohio Academy of Science held at the University of Toledo, Toledo, Ohio, on April 10 and 11, 1936; forty-one new members were elected and fifteen were raised to the rank of Fellow in the Academy.

There were two short business sessions of the Academy, some twelve or thirteen sectional meetings and a half dozen joint meetings of two or more sections, including the *Ohio Physics Club*, which, according to the custom of the past few years, met with the *Section of Physics and Astronomy*. The tendency toward joint meetings of the sections was quite evident from the printed program and was amply justified by the results, it appears. The general scientific sessions of the Academy were reduced to a minimum—only one. At this one meeting the Academy had the rare privilege of hearing an address abundantly illustrated by lantern slides and movie films on "Endocrine Factors in Sexual Reactions of Amphibia," by Dr. Roberts Rugh, of Hunter College, New York City. The Presidential Address on "*The Concept of Natural Law in Geology*," by President Bucher, was of a higher order and was most favorably received and commented upon.

Another feature of notable value was the "*Symposium on Virus Diseases*" conducted under the auspices of the Sections of Medical Sciences and Zoology. These discussions were led by men of eminent talent and of recognized authority and aroused much enthusiasm and profitable thought and debate.

Aside from the election of officers and committeemen, the items of business of general interest to the Academy transacted at this meeting were, first, the practical approval of the Academy of a recommendation from the Executive Committee to amend the Constitution and By-Laws so as to make the membership committee a *standing committee of the Academy* through which to carry on a continuous membership drive, and second, a decision to fall in line with the newly-adopted policy of the American Association for the Advancement of Science to grant

funds for research only. The Board of Trustees of the Research Fund has been asked to prepare definite instructions for submitting requests for aid in research problems. A third item of interest was the authorizing of the incoming president to appoint a committee of five to take into consideration during the year the matter of a suitable observance four years hence of the fiftieth anniversary of the organization of the Academy and to bring in definite recommendations at the next annual meeting.

Minutes of the Business Sessions

First Session: April 10, 1936

The first business session was called to order by the President at 9:30 A. M. in the Doermann Theater, University of Toledo, with a quorum present. The President announced the appointment of the following special committees:

On Membership—K. G. A. Busch, Eugene Van Cleef, and Samuel Allen.

On Resolutions—Frederick C. Waite.

On Necrology—James P. Porter.

The reports of the Secretary and Treasurer were read, accepted and filed. By vote of the Academy, the Secretary cast a written ballot for the eight current vice-presidents to constitute a nominating committee for 1937.

The report of the Executive Committee was read by the Secretary, formally received and ordered filed.

Upon motion unanimously passed the Secretary was directed to prepare the necessary amendments to the Constitution and By-Laws to make the membership committee permanent and submit same to the next annual meeting of the Academy, this motion to serve as notice of the proposed changes.

Adjourned to meet at 8:30 A. M. tomorrow.

Second Session: April 11, 1936

The adjourned business session was called to order by President Bucher at 8:30 A. M. with a quorum present.

The report of the Trustees of the Research Fund was read by the President in the absence of the Chairman of the Board, Dr. Herbert Osborn. The Trustees expressed the hope that

any member in need of financial assistance in connection with a research problem would not hesitate to let it be known even though the amount available is small.

As usual, the Library Committee, through its chairman, Mrs. Ethel M. Miller, presented an interesting report which was received with enthusiasm and ordered filed with a vote of thanks to Mrs. Miller.

For the Committee on State Parks and Conservation, Mr. E. S. Thomas, its chairman, made a very complete and highly entertaining report which was received with appreciation and ordered filed.

The Secretary then read the report of the Committee on the Election of Fellows as published elsewhere in these Proceedings.

For the Membership Committee Dr. K. G. A. Bush reported having received 41 applications for membership in the Academy and as all were in due form and accompanied by one year's dues the committee recommended their election to full membership. Report received and recommendation approved.

The report of the Joint Administrative Board, Ohio Journal of Science, prepared by C. G. Shatzer and E. L. Rice, was read by Prof. L. H. Snyder, editor of the Journal, formally received and ordered filed.

Dr. A. E. Waller, representative of the Academy on the Save Outdoor Ohio Council, reported for that organization. His report appears elsewhere in these Proceedings.

For the Nominating Committee, Prof. Robert S. McEwen, chairman, made the following report:

For President.....CHARLES A. DOAN

For Vice-Presidents—

A. Zoology.....A. W. LINDSEY
B. Botany.....CLAUDE E. O'NEAL
C. Geology.....FRED FOREMAN
D. Medical Sciences.....R. A. KNOUFF
E. Psychology.....GARRY C. MYERS
F. Physics and Astronomy.....G. E. OWEN
G. Geography.....REUEL B. FROST
H. Chemistry.....ALBERT P. MATHEWS

For Secretary.....WILLIAM H. ALEXANDER
For Treasurer.....A. E. WALLER
For Executive Committee.....W. H. BUCHER, H. H. M. BOWMAN

For Publications Committee and Administrative Board	E. L. RICE C. G. SHATZER R. V. BANGHAM
For Board of Trustees	WILLIAM L. EVANS
For Library Committee	W. H. SHIDELER
For State Parks and Conservation	E. R. HAYHURST EDMUND SECREST L. E. HICKS

The report was received and motion duly passed instructing the Secretary to cast the unanimous vote of the Academy for the nominees mentioned.

Following the report of the Nominating Committee, the attention of the Academy was called to the recommendation from the Executive Committee to the effect that some action be taken at this meeting looking toward a suitable observance of the fiftieth anniversary of the founding of the Academy and after some discussion, Dr. F. C. Waite made the following motion:

> "That the incoming President appoint a preliminary committee of five on plans for the celebration and that this committee be charged to make a definite report of plans at the meeting next year."

The Secretary then asked if the Academy wished to select a representative on the Council of the American Association for the Advancement of Science at the Atlantic City meeting next December or to express its wish as to time and place of the next meeting. Upon motion duly passed these matters were referred to the Executive Committee with power but not before Dr. R. V. Bangham, on behalf of the College of Wooster, expressed the hope that the Academy would meet in Wooster next year.

Adjourned at 9:25 A. M.

THE SCIENTIFIC SESSIONS

GENERAL AND SECTIONAL

The following is a list of the addresses and papers presented at the general and sectional meetings of the Academy as reported to the secretary, viz.:

1. THE PRESIDENTIAL ADDRESS: The Concept of Natural Law in Geology.....WALTER H. BUCHER
2. THE INVITATION ADDRESS: Endocrine Factors in Sexual Reactions of Amphibia.....DR. ROBERTS RUGH
3. Notes on Ohio Ladybird Beetles (*Coccinellidae*).....WILLIAM C. STEHR
4. A Useful Method of Labeling Geological and Paleontological Specimens, MARY AUTEN

5. A Study of Certain Groups of the Genus Thamnotettix, DWIGHT M. DELONG
6. A Study of the Male Genital Characters of the Genus Draeculacephala (Homoptera, Cicadellidae), DWIGHT M. DELONG AND RALPH H. DAVIDSON
7. Initial Temperature Effect upon the Rate of Differentiation of Whitefish Embryos.....JOHN W. PRICE
8. Anomalies in Whitefish Embryos Induced by Extreme Temperatures, WALTER M. STOUT
9. The Respiratory Mechanism of *Thyone briareus*.....ROBERT A. BUDINGTON
10. Cytological Observations on the Relation Between the Acini and the Islets of Langerhans in the Rat Pancreas.....S. D. NEILSEN
11. Barnacles of Hawaii.....J. PAUL VISSCHER
12. Responses of Chick Gonads to Gonadotropic Hormones...W. R. BRENEMAN
13. Chromatophore Studies in the Vermillion-spotted Newt, KENNETH L. KELLEY
14. Early Development of the Swim-bladder in *Hemichromis bimaculata*, ROBERT S. MCEWEN
15. A Revision of the Planarian Genus Phagocata.....JAMES A. MILLER
16. Reduction of Janus Green in *Limnodrilus Claparedianus*..JAMES A. MILLER
17. Constant Temperature Record of Surface Water in Lake Erie and its Relation to Dissolved Oxygen and Carbon Dioxide, FREDERICK H. KRECKER
18. Seasonal Changes in the Size and Activity of Thyroid Glands in Wild Birds.....S. CHARLES KENDEIGH
19. Relationships between Blood Sugar and Torpidity in Certain Hibernating Animals.....JOHN M. CONDRIN
20. Activity Rhythms in Goldfish.....WILLIAM KIEFFER
21. Experimental Rearing of Whitefish in Ohio State Fish Farms in 1935, T. H. LANGLOIS
22. The Use of Paraldehyde and Benzyl Alcohol Mixture as an Anesthetic for Laboratory Animals.....W. R. BRENEMAN AND EDWARD LEDERMAN
23. Merriam's Life Zones and the Distribution of Ohio Orthoptera, EDWARD S. THOMAS
24. Wildlife Sanctuaries Sponsored by the Ohio Academy of Science in Southern Ohio.....FLOYD B. CHAPMAN
25. A Suggested Quail Management Program in Ohio, LUTHER L. BAUMGARTNER
26. On Bird Migration "Waves".....LYNDS JONES
27. Returns from Fish Tagged in Ohio.....E. L. WICKLIFF
28. Artificial Lakes in Ohio.....LEE S. ROACH
29. The Bird Population of a 65 Acre Tract of Beech-Maple Forest Near Cleveland.....ARTHUR B. WILLIAMS
30. Low Dams and Their Effect on Stream Conditions.....LEE S. ROACH
31. Suggested Modifications for Stream Cleanup Projects.....E. L. WICKLIFF
32. Applications of Pollen Analysis in Semi-arid Climates.....PAUL B. SEARS
33. Progress of Barberry Eradication in Ohio.....HARRY ATWOOD
34. The Pathologic Races of Wheat Stem Rust in Ohio, W. G. STOVER AND HARRY ATWOOD
33. Barberry Seedling Survival at Maumee, Ohio.....W. G. STOVER
36. Southern Appalachian Flora in Jackson County.....LESLIE L. PONTIUS
37. The Alkaline Raised Bogs of Ohio and Indiana.....ROBERT B. GORDON
38. Report on the State Herberium and New Records of Ohio Vascular Plants.....JOHN H. SCHAFFNER
39. The Behavior of Chlorophyll in the Green Leaf.....ONDESS L. INMAN
40. Methods of Obtaining Evidence of Achievement of Student in Relation to Various Objectives of Botany Teaching.....CLARK W. HORTON
41. Somatic Development with Reference to the "Multinucleate Phase" and "Phragmosphere" Formation.....R. T. WAREHAM
42. The Status of *Arundo bambos* L.....F. A. MCCLURE
43. Conidial Variation in Some Imperfect Fungi.....CONST. J. ALEXOPOULOS
44. A Note on Epiphytic Algae on the Roots of an Orchid..H. H. M. BOWMAN
45. Apomixis in Iris.....A. E. WALLER
46. Some Structural Changes in Soy Bean Plants Grown from Seeds Irradiated with Soft X-Rays.....THEO. P. LONG AND H. KERSTEN
47. Champaign's Guardian of Biological History, (Presented by title), MARGARET B. CHURCH

48. Rare Stylolites.....PARIS B. STOCKDALE
49. Portersville Member of the Conemaugh Formation in Muskingum County, Ohio.....WILSON M. LAIRD
50. Some Allegheny Cephalopods from Eastern Ohio...MYRON T. STURGEON
51. *Triarthrus eatoni* in the Eden of Ohio.....HARRY J. KLEPSER
52. Some Aspects of Acidizing Oil Wells.....P. E. FITSGERALD
53. Outline of the Section of Geology Spring Field Trip.....GRACE A. STEWART
54. Some Geological Relationships of the Soils of Great Britain, G. W. CONREY
55. Silting in the Muskingum College Lake.....G. ROBERT HALL
56. Observation of Wave Action along the Shores of Lake Erie, WILLIAM H. GOULD
57. The Glacial Beaches in Lucas County.....J. ERNEST CARMAN
58. A Reclassification of the Paleozoic Systems of Michigan....G. M. EHLERS
59. Some Economic Aspects of Chert in Mineral Aggregates, HERBERT F. KRIEGE
60. Lewis Hills Overthrust, Western Newfoundland.....JOHN R. COOPER
61. A Preliminary Report on the Igneous Intrusions in the Vicinity of Monterey and Hightown, Highland County, Virginia.....FRED FOREMAN
62. Permian-Carboniferous Boundary in Ohio.....WILLARD BERRY
63. Foundation Exploration for the Muskingum Watershed Conservancy Dams.....HENRY G. MARTIN

SYMPOSIUM ON VIRUS DISEASES

64. The Nature of Viruses with Special Reference to Plant Viruses, by JORGEN M. BIRKELAND, PH. D., Assistant Professor of Bacteriology, Department of Bacteriology, Ohio State University.
65. The Use of the Foetus as an Experimental Animal for Virus Studies, by ORAM C. WOOLPERT, PH. D., M. D., Assistant Professor of Bacteriology, Department of Bacteriology, Ohio State University.
66. The Cultivation of, and Immunological and Clinical Studies with, the Virus of Lymphogranuloma Inguinale, by JOSEPH T. TAMURA, PH. D., Department of Bacteriology and Hygiene, University of Cincinnati.
67. Factors of Resistance and Immunity in Poliomyelitis, by N. PAUL HUDSON, PH. D., M. D., Professor and Chairman of the Department of Bacteriology, Ohio State University, EDWIN H. LENNETTE AND FRANCIS B. GORDON, Department of Hygiene and Bacteriology, University of Chicago.
68. Epidemiologic Considerations in the Field of Virus Diseases with Special Reference to the Common Cold and Influenza, by J. A. DOULL, M. D., D. P. H., Professor and Director of the Department of Hygiene and Public Health, Western Reserve University School of Medicine.
69. Locating the Basal Age on the Stanford Revision of the Binet-Simon Scale by Means of the Vocabulary Test.....W. E. MCCLURE
70. The Effect of Point of View in a Ranking Test.....J. J. SMITH
71. The Relation of Length of Material and Other Factors to Exposure Time in the Perception and Memory for Visual Forms, WILLIAM C. SCHWARZBEK
72. Further Study of the Childhood Environmental Determinants of Adolescent Personality.....ROSS STAGNER
73. Abuse of the Genetic Viewpoint.....H. B. ENGLISH
74. An Attempt to Measure the Effectiveness of White Space in an Advertisement on the Basis of Actual Sales.....MELVIN RIGGS
75. Effect of Various Incentive Conditions on Work Out-put.....J. S. KOUNIN
76. The Breakdown of a Discrimination Habit and Its Bearing upon Reminiscence.....AMOS C. ANDERSON
77. The Influence of the Figure-Ground Relation in Memorizing Visual Forms.....OTIS D. KNIGHT
78. Brain Potentials in Children and Adults.....DONALD B. LINDSEY
79. A New Approach to the Study of Traffic Behavior.....S. E. HAVEN
80. A New Type of Timing Apparatus and its Application in the Training of Runners.....S. M. HOWARTH AND B. M. DAVIS
81. The Influence of Note-taking upon the Comprehension of Certain Textbook Materials.....C. D. MATTHEWS
82. Age Differences in Productivity: "Best Books".....H. C. LEHMAN
83. Size Constancy in Visual Objects.....BEVERLY E. HOLIDAY

84. Sources of Moral Judgments of Under-Privileged Children, GORDON HENDRICKSON
85. A Critical Evaluation of Some Class-Room Learning Problems, GARRY C. MEYERS
86. Identification of Harmonics at Radio Frequencies.....RICHARD HOWE
87. Interpretation of Star Counts in Obscure Regions.....FREEMAN D. MILLER
88. Absorption Spectra of Some of the Simpler Porphyrins, V. M. ALBERS AND H. V. KNORR
89. Electrical Contact.....T. H. OSGOOD
90. Further Studies with Negative Hydrogen Ions, PAUL F. DARBY AND WILLARD H. BENNETT
91. Sharpness and Speed of Photographic Lenses, J. A. BING AND C. O. DELUNG
92. The Ultra-Violet Absorption Spectrum of Nitrogen.....J. J. HOPEFIELD
93. Time Measurements on Photographic Shutters...L. E. KOESTER AND I. SEFF
94. Study of Electrolytic Dissociation of $KHSO_4$ by Raman Effect, DONALD M. CAMERON AND WAVE H. SHAFFER

JOINT MEETING WITH OHIO PHYSICS CLUB AND CHEMISTRY SECTION

95. Internal vs. External Symmetry in Crystals.....F. C. BLAKE
96. Fluorescence and Photo-decomposition of Chlorophyll *a* and *b* under Atmospheres of O_2, CO_2 and N_2.....H. V. KNORR AND V. M. ALBERS
97. Some Remarks on Waves and Corpuscles.....A. LANDE
98. A System of Isotopes.....HAROLD B. LAW
99. The Nature of the Metallic State.....W. CONRAD FERNELIUS
100. Some Properties of Deuterium Oxide.....JOHN S. RICHARDSON
101. Artificial Radioactivity.....HERRICK JOHNSTON

JOINT EDUCATIONAL PROGRAM WITH OHIO PHYSICS CLUB AND CHEMISTRY SECTION

102. Projects in Chemistry III. Projects in the Teaching of Chemistry Course.....K. G. BUSCH
103. Series and Parallel Resonance Circuit for Lecture.....RAY LLOYD
104. Comparison of Vacuum Tubes for Use as Direct Current Amplifiers, GEO. H. GABUS
105. Stimulation of Student Interest in Physics.....JOHN MESCHER
106. Discovering Laws in the Elementary Laboratory.....H. P. KNAUSS
107. Laboratory Apparatus.....DON SMITH
108. Two Simple Classroom Experiments.....JOHN P. KARBLER
109. New Free Fall Apparatus.....NOLAN BEST
110. The Luminosity of Stars of High Axial Rotation.....J. A. HYNEK
111. X-Ray Energy Levels.....S. J. M. ALLEN
112. Aerial Phytography and Map Revision.....MAJOR FRED L. SMITH
113. The Westerville, Ohio, Area: An Interpretation of Field Data, JOHN H. GARLAND
114. The Functional Pattern of Barberton, an Industrial Suburb of Akron, Ohio.....JAMES R. BECK
115. The Evaluation of Soil Deterioration and Improvement in a Land Use Program.....G. W. CONREY
116. Geographic Aspects of Coal Cargoes from Toledo.....WALTER G. LEZIUS
117. Finnish Population Movement in Ohio.....EUGENE VAN CLEEF
118. Physical Influences on Economic Pressures in Ohio....KYLE W. ARMSTRONG
119. Physical Factors Affecting Land Use in Central Massachusetts, GUILBERT R. GRAHAM
120. The Resettlement Project of the Matanuska Valley in 1935, C. C. HUNTINGTON
121. Schott's Natural Regions of the Oceans: A Review.....PRESTON E. JAMES
122. The Delusion of the Colonial Argument.....W. R. MCCONNELL
123. Can Germany be Self-sufficient?.....CLARENCE HESKETT
124. Early Geographic Adjustments in the Wellington Settlement, New Zealand.....WILFRED G. RICHARDS
125. Recent Trends in the Foreign Trade of Japan.....DANIEL R. BERGSMARK

126. The Precipitation of Barium Sulfate in Alkaline Solutions, CLYDE A. HUTCHISON AND H. V. MOYER
127. The Determination of Atmospheric Pollution. A Demonstration, PHILIP R. FEHLANDT
128. Gasoline Explosion Investigation, ALBERT R. MORRISON AND JAMES R. WITHROW
129. New Synthetic Porphyrins.....PAUL ROTHEMUND
130. Thermodynamic Investigation of Flash Evaporation of Potassium Sulphate Liquors from Polyhalite. Accuracy of International Critical Tables Data on Heat of Formation of Potassium Sulphate Solutions, JOSEPH PATRICK CREAGH AND JAMES R. WITHROW
131. The Value of Chemistry in Determining the Mineral Constituents of Our Common Rocks.....WILBER STOUT

JOINT MEETING WITH THE SECTION OF PHYSICS AND ASTRONOMY AND THE OHIO PHYSICS CLUB

132. Joint Education Program with Section of Physics and Astronomy and the Ohio Physics Club.
133. Trip of Inspection by the Chemistry Section to the Owens-Illinois Glass Research Laboratory.
134. This recently built laboratory is made entirely of glass blocks, is insulated with glass wool, and has no windows. This trip should be of great interest to all chemists and also others interested in science.

REPORTS

Report of the Secretary

TOLEDO, OHIO, April 10, 1936.

To the Ohio Academy of Science:

The general duties of a secretary are well known and therefore need not be reviewed at this time. Details too numerous to mention, a rehearsal of which would be inexcusably tedious and might even "bore you to extinction;" we will therefore content ourselves with a few high spots, reserving for ourselves the Congressional privilege of extending our remarks for the record!

The secretary's work does not end with the adjournment of the annual meeting; the proceedings must be prepared for filing and publication; newly elected members, fellows and officers must be notified, and a suitable report for publication in *Science* must be prepared. All these things we did to the best of our ability and as promptly as possible. See *Science* of May 27, 1935.

We represented the Academy as best we could on the Council of the American Association for the Advancement of Science at St. Louis, Mo., last December; also at the Academy Conference, being elected and now serving as the President of this latter organization. We secured for the Academy a cash allowance of $124.00 for the year 1935, on the ground that the Academy was not in a position to avail itself of the grant for research owing to the short notice of the change in policy on the part of the A. A. A. S.

As chairman of the program committee we have co-operated cheerfully and most delightfully with the vice-presidents in the collection of the program material and the making of the program which you have in your possession. The results of the committee's effort speak for themselves. We have also co-operated in an effort to secure new members for the Academy and we wish once again to emphasize this very essential matter. The old stand-bys are leaving us; recruits must be secured!

And now for about the thirteenth time, your secretary wishes to record his very high appreciation of the fine co-operation he has had from the members and officers of the Academy in his efforts to discharge the duties of his office; the associations have been delightful and the memory of these will be fragrant in the months and years to come. This is our greatest reward!

Respectfully submitted,

WILLIAM H. ALEXANDER,
Secretary.

Report accepted and ordered filed.

Report of the Treasurer

RECEIPTS

Cash on hand, January 1, 1935		$ 594.64
Receipts from the Sale of Publications	$ 55.60	
Received from A. A. A. S.	124.00	
Interest on Bonds	479.76	
Dues from Members, Back Dues Collected	503.50	
Total Receipts		1,237.27
Total		$1,831.91

DISBURSEMENTS

Expense to Executive Committee Meetings	$ 7.80
Spahr & Glenn Co., Printers	101.71
Ohio Journal of Science	1,230.01
Membership, Save Out Door Ohio Council	8.00
Postage for Secretary's and Treasurer's Office	22.50
Clerical Help, Secretary's and Treasurer's Office	77.71
Expenses of Vice-Presidents	35.81
Safety Deposit Box	3.30
Program, Committee Meeting, Expenses	12.63
Secretary's Honorarium	100.00
Flowers for 1935 Annual Dinner	2.00
Tickets for 1935 Annual Dinner	2.32
Stenographic Report of 1935 Business Meeting	10.40
Auditing 1934 Report	17.50
Returned Check and Bank Charges	4.63
Total Disbursements	$1,636.32

Total Receipts	$1,831.91
Total Disbursements	1,636.32
Balance	$ 195.59

Respectfully submitted,

A. E. WALLER,
Treasurer.

Report of Auditor

To the Ohio Academy of Science:

I have audited the report of the Treasurer of the Ohio Academy of Science for the year 1935–36 and have found the following statements to be true:

Cash on hand, January 1, 1935	$ 594.64
Add: Receipts for the year 1935–36	1,237.27
	$1,831.91
Less: Disbursements for the year 1935–36	1,636.32
Cash Balance, January 16, 1936	$ 195.59
Balance in Huntington National Bank, January 16, 1936	$ 195.59
Less: Outstanding Checks	(None)
Cash Balance, January 16, 1936	$ 195.59

OHIO ACADEMY OF SCIENCE BALANCE SHEET

As of January 16, 1936

Assets

Current Assets:	
Cash	$ 195.59
Bonds—3% Cons. Federal Land Bank (listed at purchase price)	1,290.25
Research Fund (Schedule I)	1,923.27
	$3,409.11

Liabilities and Net Worth

Net Worth:	
Surplus	$3,409.11

Research Fund

Schedule I.	
Cash Balance, January 1, 1935	$ 200.40
Add: Receipts for Year 1935–36 (Dividends and Interest)	86.25
	$ 286.65
Less: Disbursements for year 1935–36.	
Lorain Urban Survey and Bank Charges	100.88
Cash Balance, January 1, 1935	$ 185.77
Bank Balance, January 1, 1935	$ 185.77
Less: Outstanding Checks	(None)
Balance, January 1, 1935	$ 185.77
Cash Balance	$ 185.77
Bonds, 5% (listed as at purchase price)	1,300.00
BancOhio Stock, 25 shares	437.50
Total Research Fund	$1,923.27

I certify that the above statements are, in my opinion, true and correct and correctly set forth the results of the operations of the Ohio Academy of Science for the year January 1, 1935, to January 1, 1936.

Respectfully submitted,

Delber Kinsel,
Fraternity Auditor.

Report of the Trustees of the Research Fund

December 19, 1936.

Mr. W. H. Alexander, Secretary,
Ohio Academy of Science.

DEAR MR. ALEXANDER:—I submit herewith statement of the Academy Research Fund as of present date and, as there are no commitments or anticipated changes before the end of the month, present the account for the annual audit in this form. As I expect to leave Columbus before the end of the year and as I may not be in attendance at the spring meeting of the Academy this account may be submitted as the annual report, although I may wish to make an additional statement at that time.

SUMMARY OF CREDITS

Balance in Checking Account January 1, 1935	$200.40
Receipts from Interest and Dividend Payments	86.25
Total	$286.65

DISBURSEMENTS

Grant to R. B. Frost toward Lorain Urban Survey	$100.00
Service Charges, Ohio National Bank	.88
Balance in Checking Account, Ohio National Bank	185.77
Total	$286.65

STATEMENT OF INVESTED ASSETS

Bonds (listed as at purchase price), 5% Income	$1,300.00
25 Shares BancOhio Stock (listed at purchase price)	437.50
Total	$1,737.50

Receipts from our bonds are now at the rate of 5% and the latest information I have is that the BancOhio stock is quoted at above the price we paid and we receive quarterly dividends regularly.

Our securities are deposited for safe keeping and the checking account is carried by the Ohio National Bank, 167 South High Street, Columbus, where confirmation of these figures may be obtained for the audit. Mr. Kenneth T. Whitaker, who has looked after the Academy finances since Dr. Mendenhall was in charge of the Research Funds, may be consulted for ready attention to audit enquiries.

Respectfully submitted,

HERBERT OSBORN,
Chairman, Research Fund.

NOTE.—If you will give your auditor a note certifying his authority to examine the deposits at Ohio National Bank, I am sure he will find ready attention.

H. O.

Report of the Executive Committee

(By the Secretary)

TOLEDO, OHIO, April 10, 1936.

To the Ohio Academy of Science:

The Executive Committee held three meetings during the year with all members present: One on December 7, 1935, one on January 18, 1936, and the third, last evening at the Secor Hotel in Toledo, Ohio. At the first meeting, there were present by invitation Dr. Herbert Osborn, chairman of the board of trustees of the Research Fund; Dr. E. N. Transeau, representing the Ohio State University on the Administrative Board, Ohio Journal of Science; Dr. L. H. Snyder, editor of the Ohio Journal of Science; and Dr. B. S. Meyer, business manager of the Ohio Journal of Science.

The primary purpose of this meeting was to consider certain financial matters in connection with the Ohio Journal of Science. After a full, frank statement of facts by the four gentlemen mentioned and after ample, free and frank discussion by the Committee, it appearing that a real crisis had developed in the financial affairs of the Ohio Journal of Science, the following motion was unanimously passed by the Executive Committee, viz.:

> "That the Treasurer be authorized and directed to pay out of the reserve fund the sum of $700.00 into the fund of the Ohio Journal of Science, $450.00 of this amount to meet bills now due and $250.00 to pay for the next issue of the Journal."

The Treasurer reported a reserve fund of some $1,700.00. He was instructed by the Committee to invest the balance in U. S. Treasury Certificates.

At this meeting it was unanimously decided to accept the invitation of the University of Toledo to hold the 46th annual meeting within its walls.

The question of inviting the Michigan Academy of Science to meet with the Ohio Academy at Toledo was considered favorably and the Secretary was asked to look into the feasibility of such a joint meeting, if not this year, then next.

The Secretary was selected to represent the Academy on the Council of the American Association for the Advancement of Science and at the Academy Conference of the A. A. A. S.

At the second meeting the Secretary made a partial report of his actions as representative of the Academy at the St. Louis meeting of the A. A. A. S., the chief item being the securing of a cash allowance of $124.00 instead of funds for research only. The Secretary was elected President of the Academy Conference.

In view of this rather fundamental change in the financial arrangements between the Association and the Academy the Committee felt that action should be taken to advise the membership, especially those thinking of making application for research funds, that all such applications must be in the hands of the Secretary or Chairman of the Board of Trustees not later than the annual meeting of the year in which the

solicited funds are to be used. A suitable form on which to make application for said funds is to be prepared indicating in a general way the information desired by the Academy from those applying for the funds.

The matter of delinquent dues was freely though sympathetically discussed, the discussion culminating in a request that the Treasurer send a tactful letter at once to all delinquents requesting them to indicate their wishes or intentions regarding back dues, assuring them of the Academy's willingness to accept any reasonable adjustment of same.

The question of a membership campaign was raised and the committee went on record as favorable to same and to this end it was suggested that provision be made in the Constitution or By-Laws for a standing membership committee.

A third meeting was held last evening at the New Secor Hotel, Toledo, Ohio, with all members present except the President, who was not feeling well and asked to be excused. As the result of the deliberations at this third meeting the following recommendations are made to the Academy:

1. That the necessary changes be made in the Constitution and By-Laws to provide for a permanent committee on membership.
2. That action be inaugurated at this meeting looking toward a suitable observance of the Fiftieth Anniversary of the organization of the Academy four years hence and to this end the committee suggests the appointment of a special committee of ways and means, committees, etc., to make report with recommendations at the next annual meeting of the Academy.
3. That the Board of Trustees be asked to prepare a suitable form for use in applying for research funds.

Respectfully submitted,

WILLIAM H. ALEXANDER,
Secretary.

Report accepted and ordered filed.

Report of the Library Committee

COLUMBUS, OHIO, April 10, 1936.

To the Ohio Academy of Science:

The report of the chairman of this committee for last year stated that a systematic check was then being made upon the exchanges to ascertain whether they were being received regularly at the Ohio State University library, as it had been several years since this had been done, but that no report could be given at that time. The results were just what one would expect. Most of the exchanges are coming regularly; a few had taken the name of the University Library off their mailing lists but were willing to replace it when the matter was called to their attention, and some were such that it seemed desirable for one reason or another to drop them from our mailing list. One name was transferred from the subscription list of the Ohio Journal of Science to the

exchange list as this organization has presented valuable bound books and serials to the Ohio Academy of Science for years but yet has been purchasing its copy of the Ohio Journal of Science. Fourteen exchanges were dropped and seven new ones secured. The number is now 375. As many of them send more than one title on exchange the number of periodicals and serials which are received in this way is between five and six hundred with a value of a thousand to twelve hundred dollars.

Routine work has been carried on as usual, such as claiming exchanges that failed to arrive at the proper time, changing addresses on the mailing list, adding new names and removing a few. A little more reference work than usual has been done at the request of a few of the Ohio Academy of Science members. The chairman of this library committee is very glad to be called upon for such library work as it is possible for her to do. No guarantee is made that the results will be entirely successful but the assurance is given that every possible effort will be made to secure the desired information.

The sales of publications amounted to $50.05, which was a substantial increase over the sum of $32.30 for the preceding year. The number of sales for each year remained the same, twenty-six, but the number of papers sold increased from 50 in 1934 to 88 in 1935. One sale of a complete set of the forty Annual Reports and all but five of the twenty-one Special Papers, amounting to $23.70, made a good addition to the total sales. This set was purchased by Kent State College last April. Another nearly complete set was purchased this year by the Toledo Public Library. This made a good beginning for the 1936 sales and its amount of $26.30 will appear in next year's report. Only four sales were made to places outside of our own state.

The "Batrachians and Reptiles of Ohio" gained first place in popularity this year with the "Fishes of Ohio" next. The two papers which tied for first place last year fell to fourth place this year, showing how variable the demand is from year to year.

During the year the sum of $55.60 has been given to the Treasurer of the Academy. This included a balance of $6.05 on the 1934 sales and $49.55 on the sales for 1935. One bill for fifty cents is still outstanding. A paper was sold to a certain department of the Ohio State University and it will unquestionably be paid for when the unusual financial conditions now existing at the University are remedied.

The sum of $30.09 still remains in the name of the Ohio Academy of Science in the Buckeye State Building and Loan Company. This could be withdrawn as the company is now paying on stock accounts at the rate of twenty-five dollars a month, but as it was not drawn out before the first of the year it does not appear on the Treasurer's report.

Continuing the policy of last year no formal financial statement is being given in this report, but it has been duly made and is on file for the purpose of record.

Respectfully submitted,

Ethel Melsheimer Miller,
Chairman.

Report of the Joint Administrative Board of the Ohio Journal of Science

COLUMBUS, OHIO, April 10, 1936.

To the Ohio Academy of Science:

A meeting of the Joint Administrative Board was called together at 4:15 P. M. on November 16, 1935, by Chairman Rice. Present were all members of the Administrative Board, the Editor and the Business Manager of the Journal. The Business Manager presented a statement of the present financial situation of the Journal which was followed by a prolonged discussion by members of the Board.

Motion carried that the Administrative Board of the Journal approach the Executive Committee of the Ohio Academy of Science, explain to them the present financial difficulty of the Journal and request (1) payment of the Journal's share of the Ohio Academy of Science dues for the current year to date, drawing if necessary upon the reserve fund of the Academy for this payment, and (2) advance $250.00 of the 1936 payment of the Academy in order to help defray cost of publishing the November issue of the Journal and thus avoid the present deficit in the Journal's funds due to a delay in the payment of the second half of the 1935 University grant to the Journal resulting from the Governor's vetoes.

The meeting adjourned at 5:15 P. M.

A second meeting was held on April 10, 1936. Present were Messrs. Rice, Transeau, Shatzer and Snyder. Chairman Rice presided. The Business Manager's report was presented, as follows:

THE OHIO JOURNAL OF SCIENCE
FISCAL YEAR 1935

RECEIPTS

Balance from 1934	$ 317.32
University Grant	375.00
Ohio Academy of Science	600.00
Ohio Academy of Science—Proceedings, 1935	143.55
Ohio Academy of Science Research Fund (for paper by R. B. Frost)	100.00
R. B. Frost, for Printing Special Paper	75.00
Ohio State Chapter Sigma Xi—Symposium Number	266.81
Subscriptions	85.25
Sale of Individual Copies and Volumes	67.50
Authors Payments for Plates and Publication Out of Order	80.46
	$2,110.89

EXPENDITURES

Spahr & Glenn Co., First Five Numbers, Volume 35	$1,377.52
Bucher Engraving Co	448.90
Postal Charges	122.41
Envelopes	32.50
Clerical Assistance	10.60
Refund on Subscription	2.00
Bank Charges	1.23
	$1,995.16
Balance on hand February 29, 1935, Huntington National Bank	115.73
	$2,110.89

As of present date the bill for the November, 1935, number of the Journal, amounting to $212.90, is still unpaid. All other 1935 bills are paid.

The report was accepted and placed on file. The present financial status of the Journal resulting from the Governor's vetoes was discussed. Since it appeared that the University payments would eventually be made, a motion prevailed that the Journal continue normal publication for the time being, at least.

Respectfully submitted,

B. S. MEYER, *Secretary,*
Joint Administrative Board of the Ohio Journal of Science.

Report of the Save Outdoor Ohio Committee

COLUMBUS, OHIO, April 11, 1936.

To the Ohio Academy of Science:

The reorganization of the Save Outdoor Ohio Council was completed in time to align its activity with the present interest in conservation which both State and Federal Government agencies are showing. The new attitude toward conservation on government's part may be said to be widespread rather than deep. If this public vaccination with conservation is to take, public education in biology applied to human affairs is needed and badly needed. For it is plain that since conservation means different things to different men, the expenditures of enormous sums have often been at cross purposes. For example, stream clean up, a W. P. A. project, for which the Federal Government allotted one million, eight hundred thousand dollars, was quickly shown to be destructive to plant and animal life along the banks and to the plants and animals of the stream. Even worse, it is a contributing factor to water erosion in flood periods. With the advice of members of the Save Outdoor Ohio Council and the State Conservation Division the program was somewhat improved. It was not stopped entirely, of course. However, the great point was gained that the advice of the Conservation Division was given some consideration.

The plan of beginning education in conservation early is being forwarded by the Save Outdoor Ohio Council and the Division of Conservation. Just how far this will go cannot be predicted. The use of any material is optional with the schools. However, there is available from W. P. A. funds forty-six thousand dollars for materials to schools, scout troops, clubs, etc. It might be suggested that here is a chance for the members of the Ohio Academy of Science to co-operate more fully with the Save Outdoor Ohio Council and to see that really conservative practices are discussed. There has been a total reversal of judgment with respect to "vermin" which included some of the hawks and other predatory birds. There is probably a better appraisal of "weeds" which may include plant life suited to stop the erosion of top-soil layers.

The success of the Save Outdoor Ohio Council in an advisory

capacity is purely to be what we make of it. The more co-operation that is offered the better it will work. A meeting held November 22, 1935, giving an opportunity to hear a number of papers on different aspects of conservation was well attended and well received.

We have continued and expect to continue our membership in the Council. This entitles us as a committee to one vote in the Council. Actually our co-operation is much closer, as many Academy members are active in the Council as an examination of the above list of speakers serves to show.

Respectfully submitted,

A. E. Waller,
Representative.

Report of Committee on Election of Fellows

Columbus, Ohio, April 11, 1936.

To the Ohio Academy of Science:

The following members were elected to Fellowship in the Academy:

Clyde Stewart Adams
Donald Joyce Borror
Richard Bradfield
Karl G. A. Busch
W. Storrs Cole
Ralph Howard Davidson
Willis Conard Fernelius
Margaret Fulford
Jesse R. Harrod
Edwin Elmore Jacobs
Josef Nissley Knull
William A. Manuel
John Alden Miller
Nicholas Mogendorff
Paul W. K. Rothemund

Respectfully submitted,

W. H. Alexander,
Secretary.

Report of the Trustees of the Research Fund

April 11, 1936.

To the Ohio Academy of Science:

During the past year your trustees have allowed one grant of one hundred dollars and the additions as of December 31st were $85.25, which left in checking account $185.77, which with additions since audit will allow something over $200.00 available for grants or investment. The following summary shows the condition of the fund at January 1, 1936.

Receipts

Balance in Checking Account, January 1, 1935	$200.40
Receipts from Interest and Dividend Payments	86.25
Total	$286.65

Disbursements

Grant to R. B. Frost toward Lorain Urban Survey	$100.00
Service Charge, Ohio National Bank	.88
Balance in Checking Account, Ohio National Bank	185.77
Total	$286.65

STATEMENT OF INVESTED ASSETS

Bonds (listed at purchase price)	$1,300.00
25 Shares BancOhio Stock (at cost)	437.50
Total	$1,737.50

In case the plan of the A. A. A. S. to have its grant to the Academy available for research projects it will be desirable to have approved projects in view and your Trustees will welcome suggestions. Also additions to the Research Fund from any source will be most welcome as we feel that there will be ample opportunity to use the fund to advantage.

Respectfully submitted,

GEO. D. HUBBARD,
ALPHEUS W. SMITH,
HERBERT OSBORN, Chairman,
Trustees.

Report of the Committee on Necrology

April 11, 1936.

To the Ohio Academy of Science:

Your committee notes with regret the loss of the following members since the last annual meeting:

JANE M. DOREN, Columbus; joined the Academy in 1909, died in 1935 or 1936.

W. H. AIKEN, Cincinnati; joined the Academy in 1898, died October 31, 1935.

WILLIAM C. WERNER, Painesville; a charter member, joined in 1891, made a fellow in 1922, died 1935 or 1936.

THOMAS A. BONSER, Spokane, Wash.; member of the Ohio Academy of Science from 1896 to 1909, when he moved to Spokane; died August 4, 1935; native of Dayton, Ohio.

MRS. KATHARINE D. SHARP, London; joined the Academy in 1911, made a fellow in 1928; died September 19, 1935.

JOHN U. LLOYD, Cincinnati; charter member; made a fellow in 1920; died April 9, 1936, within ten days of being 87 years old.

Respectfully submitted,

JAMES P. PORTER,
Committee.

(Upon motion, the reading of the report carried with it a proper recognition of the work of these members.)

Report of the Membership Committee

April 11, 1936.

To the Ohio Academy of Science:

Your Committee on Membership has received and examined the following applications for membership in the Academy, found same in due form, dues for one year paid, and now recommend their election to full membership in the Academy, viz.:

1. Albright, John G., (F), 1906 E. 105th St., Cleveland.
2. Alexopoulos, Constantine J., (B), Kent State University, Kent.
3. Anderson, Amos C., (E), 137 N. Congress St., Athens.
4. Barr, Dr. Daniel R., (D), Grand Rapids, Ohio.
5. Bauman, Harry, (A), 1091 Jefferson Ave., Akron.
6. Bayfield, E. G., (H), Ohio Agr. Exper. Sta., Wooster.
7. Bergsmark, Daniel R., (G), University of Cincinnati, Cincinnati.
8. Bond, Clyde H., (G), R. F. D. No. 3, Quaker City.
9. Brill, H. C. (H), Miami University, Oxford.
10. Busch, Daniel A., (C), 2424 Sherwood Rd., Columbus.
11. Davidson, Horace B., (D), Hamilton Hall, O. S. U., Columbus.
12. Deno, Richard A., (A), State University, Bowling Green.
13. Ebaugh, Dr. W. C., (H), Denison University, Granville.
14. Ehlers, G. M., (C), University of Michigan, Ann Arbor, Mich.
15. Goslin, Charles R., (B), Lancaster.
16. Harrod, J. R., (H), 115 S. Johnson St., Ada.
17. Hendrickson, Gordon, (E), University of Cincinnati, Cincinnati.
18. Hopkins, Everett H., (E), 711 N. Fountain Ave., Springfield.
19. Horowitz, Martin M. (A), 650 Carpenter St., Columbus.
20. Jones, Dr. Edgar P., (A), University of Akron, Akron.
21. Kellackey, Sister M. Celine, (B), 2035 E. 79th St., Cleveland.
22. Kelley, Kenneth L., (A), Kent State University, Kent.
23. Lamey, Carl A., (C), Dept. of Geol., O. S. U., Columbus.
24. Langlois, Thomas H., (A), 3448 N. Broadway Place, Columbus.
25. Lawson, Chester A., (A), Wittenberg College, Springfield.
26. Pappenhagen, Louis A., (H), 705 W. State St., Alliance.
27. Park, Orlando, (A), Northwestern University, Evanston, Ill.
28. Richards, Wilfred G., (G), 337 Maple St., Oxford.
29. Rothermel, Miss Julia E., (A), Western College, Oxford.
30. Schaefer, Paul E., (A), Dept. Z. and Ent., O. S. U., Columbus.
31. Schott, Ralph G., (D), B. & Z. Bldg., O. S. U., Columbus.
32. Seton, Sister Elizabeth, (A), College of Mt. St. Joseph, Mt. St. Joseph.
33. Shade, Ervin H., (H), 681 Girard Ave., Marion.
34. Shanks, Royal E., (B), North Bloomfield, Ohio.
35. Spandeau, H. M., (A and B), 97 Sherman Ave., Mansfield.
36. Strete, Ralph F., (C), Miami University, Oxford.
37. Veeder, Martha Anna (H), Western College, Oxford.
38. Watt, Lucy J., (A, B and D), Western College, Oxford.
39. Williams, Arthur B., (A), 2717 Euclid Ave., Cleveland.
40. Yunck, George F., (C), 706 Central Ave., Sandusky.
41. Zimpfer, Paul, (B), 1553 Moler Rd., Columbus.

Respectfully submitted,

K. G. A. Bush, Chairman,
Eugene Van Cleef,
Samuel Allen,
Committee.

Note: Letter in parenthesis after name indicates section of major interest.

Report of the Committee on Resolutions

April 11, 1936.

To the Ohio Academy of Science:

The Ohio Academy of Science wishes formally to express, for itself as an organization and for each of its members individually, appreciation to the authorities of the University of Toledo for the use of rooms and equipment in the conduct of meetings, and for the courtesies of its staff.

We desire to commend the accomplishments of the local committee which has provided excellent facilities for all our meetings and satisfactory arrangements for the personal comfort of visiting members at the 46th meeting.

F. C. Waite,
Committee.

Presidential Address

THE CONCEPT OF NATURAL LAW IN GEOLOGY[1]

WALTER H. BUCHER,
University of Cincinnati

Geology operates largely without the concept of "natural law." The speaker became keenly aware of this circumstance when, a number of years ago, he began his efforts to derive from rapidly accumulating knowledge concerning the geology of different parts of the earth generalizations designed to form a reliable foundation for reasoning concerning the dynamics of the earth's crust.[2] When he spoke of them as "laws of crustal deformation," he had to meet the objections of others and his own doubts. He had to view the procedure of geologic investigations in the light of the fundamental method of all science.

Some of the resulting reflections are presented here before men from many fields of science in the hope that they will lead to a clearer understanding of the nature of the geologist's work, and to that finer sympathy from which springs effective co-operation between men in different sciences upon which further progress depends in a large measure.

Geology is peculiarly dual in its aims: on the one hand it is concerned with what happened *once* at a *certain place*, in *individual* mines, mountains, regions. Interest that centers on individuals is *history*, not science.[3] As a *science*, geology is concerned with the *typical* that finds expression in *generalizations*, whether they be called laws or something else. In his actual work, the geologist described the individual and attempts to grasp its meaning in terms of the typical. If you catch him unawares, he will tell you that he tries to "explain" the "facts" of geology in terms of the "laws of physics and chemistry." But the matter is actually much more complex.

For the purposes of the following discussion, we will do well to remind ourselves first of the essence of all scientific investigation and of the structure of science at large which results from it. Then we shall look at the scientific aspect of the geologist's work and the role which the concept of natural law plays in it.

Fairfield Osborn liked to tell the story "of the little redheaded fellow he accosted in the elevator one day. "Well, my boy," said Professor Osborn, "what do you like best in the museum?" The little tot, in sepulchral voice, answered "fossils."[4] No doubt the circumstances justified the comic effect this answer produced. Yet the story sounds the funnier the less one knows about the mystery that attends the birth of a scientific career in a young mind. Every experienced worker knows of instances of children fascinated, without rhyme or reason, by

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[1]Presidential address read before the Ohio Academy of Science, at Toledo, on April 10, 1936. In the reading pages 191 to 192 were omitted. A number of minor changes have been made in the final manuscript.

[2]Walter H. Bucher, "The Deformation of the Earth's Crust. An Inductive Approach to the Problems of Diastrophism." Princeton University Press, 1933.

[3]Heinrich Rickert, "Die Grenzen der naturwissen schaftlichen Begriffsbildung," Tubingen, 1929, esp. pp. 217–237.

[4]Told by F. T. Davidson, president of the American Museum of Natural History. "Natural History," Vol. 37, 1936.

a group of objects in a museum. They come back with longing eyes and at last overcome their shyness and ask questions. They want to know.

What is it they want to know? Generally, above all, what things are called—names. Few aspects of science amuse the layman more than what he considers the child-like delight scientists take in cryptic, if not bombastic, nomenclature. There are not a few men of science, in fields less encumbered by verbiage, who are inclined to share this sentiment.

Those who are closer to the realities of the descriptive sciences know better. The plain fact is that apart from troublesome taxonomic tangles every scientific name is a code word for a group of natural laws as significant and dignified as those of any science. When the boy-who-wants-to-know is told that the crystal he is holding in his hand is quartz, he is actually told that any substance of that crystal form, luster, and fracture, always, by the inevitableness of experience which we call natural law, possesses a certain hardness, melting point, behavior towards acids, etc.[5]

If the shell he brought is *Polygyra*, he might be told, "Go back to the woods and collect a few shells just like this—they are common—but with the living animal still in it. You will find that animal possessing two pairs of tenacles, the larger ones each with an eye at the tip. You will find the mantle cavity lined with blood vessels, functioning as a lung. Dissolving the animal's head in potassium hydroxide, you will find a narrow ribbon beset with delicate teeth, many in a row, with specific shapes that can better be drawn than described, and so forth."

To the boy such predictions would seem like magic had he not been told early to accept the dry fact that all things have certain properties. The "properties" of objects are the "laws" of the descriptive sciences.

Conversely, it might be said that the "laws" of the so-called exact sciences are but expressions of "properties." When, over three hundred years ago, Kepler recognized, as a result of observations that extended over more than a decade, that the orbit of Mars is elliptical, he merely discovered a "property" of the planet's orbit. This is true even through his discovery required rare insight, being the result of keen abstractions from a very large number of observations concerning the position of the planet, and involving, furthermore, the assumption that the limited number of determinations was representative of an invariable form of the path.

In the same work (1609) in which he "described" the orbit of Mars, he published two of his bolder generalizations, the first of which stated that the orbits of all planets are ellipses. This, the first of the famous three laws of Kepler, has come down to us as a prototype of "laws." Yet it is purely descriptive.

It is true, it can be expressed in mathematical form. In that case we say, for instance, the paths of all planets are of the form $r = \frac{p}{1-\epsilon \cos \theta}$[6]

[5]H. Poincaré. "The Value of Science," in "The Foundations of Science," the Science Press, 1929, p. 333.

[6]Where r and θ are the variables in polar co-ordinates, p is the "parameter"—the length of the normal erected in the focus measured to its intersection with the curve, and ϵ the "eccentricity" ($\epsilon = \frac{r}{d}$ where d is the distance from a given line, normal to the major axis). This is the general equation for all conic sections.

But that is no reason for calling it a "law" instead of a "property." Many of the "properties" found in the descriptive sciences can be expressed no less successfully in mathematical form. The shells of nautiloid cephalopods, for instance, grow in the form of a logarithmic spiral, in other words, assume an outline such that the advancing edge follows a path of the form $r = a^{\theta}$.[7]

There is a better reason for calling some "properties" laws. It grows out of another aspect of scientific endeavor. The eager youngster in the musuem asks not only, "What?" but also, "Why?" We are ready to tell him the properties of quartz and Polygyra. But then he asks, "Why is quartz so hard?" and "Why does a radula with numerous, closely set, small teeth go with a shell such as Polygyra?" This is a more serious matter. He asked for "knowledge" before, now he calls for "understanding."

What, precisely, do we mean when we say we "understand," in matters of science? In place of giving an abstract answer, let us picture to ourselves what happened when men learned to understand a simple fact of nature, for example, the rainbow.

First of all, this common meteorological phenomenon had to be observed carefully so that it meant more than a curved streak of colors in the sky. Its properties had to be observed and defined carefully, each of which has truly the dignity of a law, such as, "rainbows are segments of circles; the center of the rainbow lies on a straight line drawn through the sun and the observor's eye; a single rainbow is always violet on the inside and red on the outside;" and so forth. But even had he had all this knowledge, Aristotle would have been unable to understand even the simplest elements of the geometry of the rainbow. He ascribed it to the reflection of the sun's rays by the rain. He must have felt as unconvinced as we do about many so-called "explanations" of present day geology. Two hundred years later Ptolemy made a good start toward a study of refraction in what has been described as "the most remarkable experimental research of antiquity."[8]

But no one seems to have noted a possible connection with the rainbow. When the scientific spirit awoke again near the end of the Middle Ages, it was recognized that rainbows owed their origin in some way to refraction, perhaps combined with reflection. Real understanding had to await knowledge of the basic law. When W. Snell discovered (in 1621) the quantitative law of refraction, Descartes was quick to apply it to the problem of the rainbow. His calculated angle agreed with that observed. Men now "understood" the geometric laws concerning the rainbow as special cases of the broader law of refraction. The colors, however, remained a mystery. There were futile attempts at explanations, of course. We would call them working hypotheses today.

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[7]Where, again, r and θ are the variables in polar co-ordinates and a is a constant.

See the chapter on logarithmic spirals (Ch. XI) in D'Arcy W. Thompson's fascinating book "On Growth and Form." Cambridge, 1917, pp. 493–586.

[8]G. Sarton. History of Science, Vol. 1, 1927, p. 274. Quoted from W. C. D. Dampier-Whetham, "A History of Science," 1931, p. 54.

Men might even have entertained "multiple hypotheses" in their search for a solution. The fact remains that no matter how large a number of multiple hypotheses was made, no solution could be found until the basic law was discovered, and cast into suitable form, upon which the solution depended. When Newton found the laws of dispersion, understanding came in a flash. "Understanding," then, as we use the word in science, consists in recognizing a specific law as the special case of a more general law.

Newton's demonstration that all three of Kepler's laws, apparently so different in content, are merely the geometrical implications of an abstraction of by far more general character, is perhaps the most illustrious example of an intrinsically great feat of understanding.[9]

Quite instinctively, certainly without any particular method, we speak of "laws" when we recognize generalizations that are fraught with possibilities of understanding—in contrast to those generalizations which establish relationships to be understood—the properties. Thus we speak of Osborn's law of adaptive radiation in biology, of Ferrel's law in meteorology, of Rosenbusch's law in petrography. The more general a law, the greater its resolving power. In order to be general, it must be abstract. The more abstract it is, the more amenable it is to mathematical treatment—the more exact is the form in which it can be stated.

The sciences that face the objects of experience in their full complexity—such as the plants, animals, rocks, topography, weather—find the mathematical language inadequate to their task. The curves defining the shape of a trilobite or of granite intrusive, like the flow lines of a weir in a river or of the air on a weather map, defy mathematical analysis. Accurate description of reality seen in nature and in experiment form the accumulated store of scientific knowledge in these sciences. From it there arise, through judicious generalizations, "specific laws" that give us the first sense of order in the concrete aspect of complex reality. Back of them, revealed by greater and greater abstraction from reality, we distinguish the more and more general laws of chemistry, physics, mechanics, electrodynamics, mathematics. This is the familiar picture of the hierarchy of the sciences. It is repeated in the structure of every branch of science.

In geology we see geophysicists, students of geotectonics, regional geologists, stratigraphers, petrographers, mineralogists gather observations that are to lead ultimately to an understanding of the complicated spectacle of the earth. Like horizontal strata of decreasing complexity, lie the levels at which these men are working, each forming at least part of the foundation for the work of those above it.

At each level laws must be formulated without which understanding is impossible at the higher levels of complexity. This is the picture the geologist must keep before him if he is to do his best work and derive the deepest satisfaction from it.

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[9]The proof with the mathematical tools that Newton had at his disposal was a very great achievement indeed. In modern vector notation the proof is quite simple and occupies not more than two pages for all three laws.
See Louis Brand, "Vectorial Mechanics." New York, 1930, pp. 401–403.

Let us now see how this works out in practice. Take the case of the igneous rocks. Observations led early to the definition of numerous types and to attempts at classification. Mineral composition and texture were studied comparatively. Here, as always, comparative studies led to generalizations which were more than mere properties of types, generalizations that had the character of the empirical laws. "Nephelite-bearing rocks are free from quartz" is one. Rosenbusch's law concerning the typical sequence of (final) crystallization, from basic to acid minerals, is another.

Not until such laws were formulated could any serious desire for explanations, for "understanding," arise. Before, it would probably have seemed rather silly to ask, "Why is a basalt constituted the way it is?" One might as well ask, "Why do radulas of the *Polygyra* type go with the shells that characterize that genus?" That is the way it is—that is all.

It would certainly have been futile to go to the classical chemistry of the last century for an answer. No number of multiple hypotheses could have led to the trail of understanding; because understanding could not even be conceived until physical chemistry had reached the state of the phase rule.

But even after the basic concepts had been created, much work had to be done before an understanding of the characteristics of mineral associations in igneous rocks became possible. The level between the abstract theory and the complex reality of the rocks had to be filled by experiment on the properties of silicate melts. Investigations in that field are expensive. Industry was slow in entering that no-man's land. When the geophysical laboratory of the Carnegie Institute of Washington was established, it undertook to fill the gap.[10] The Kaiser Wilhelm Institut für Silicatforschung in Berlin-Dahlem was modeled after it. For over three decades the work has gone on. One by one the empirical laws of petrography are becoming intelligible, if not fully understood, in the light of the properties of silicate melts. Thus formulation of empirical laws, systematic exploration of artificially simplified systems: those are the steps from which springs the understanding of reality which is the ultimate aim of science.

Let us turn to another illustration. In a sense, mineralogic-petrographic studies on igneous rocks are not typical of geologic work. The units with which they deal can be taken into the laboratory, weighed, studied under the microscope, analyzed chemically.

Geologic investigations in the strict sense of the term, on the other hand, deal with sizable parts of the earth's crust. While these are, of course, small compared with the objects studied by the astronomer, they have the disadvantage of being right up against us. They are vast compared to man's size. The amount of physical labor and time consumed in merely traversing the objects of study looms large. The methods of the surveyor and cartographer and graphic representations

[10]It is instructive to read the diverse suggestions which were received by the advisory committee on geophysics from outstanding geologists and geophysicists, at the founding of the Carnegie Institution (Year Book No. 1, 1902, pp. 44–70) and contrast with them the purposeful limitation of the work which was ultimately adopted and which has led to such uniquely valuable results.

of diverse kinds must be used to record the knowledge gained. In typical cases the work of several men and of several field seasons is required to furnish a reasonably accurate description of one object of study, one individual, if you please.

Take the case of the oil-bearing strata of the Green River shale—sediments of a long extinct lake in western Colorado, Wyoming, and Utah. In order merely to describe this stratigraphic individual adequately, it is necessary to traverse along as many lines as possible the 25,000 square miles covered by these sediments; to study the variations in the sediments, especially the near-shore phases; to measure the rhythmic lamination of the sediments, which is such a conspicuous feature of the formation, throughout the 2,000 feet of thickness and to compare the results for as many sections as possible; to look for and study carefully zones with significant minerals, such as a rather unique analcite bed and more numerous layers of other peculiar minerals; to study the nature of the organic material, chemically and above all with the microscope and microtome; to make collections, as exhaustive as possible, of the fossil leaves, insects, fishes, for which the beds are famous and to establish the taxonomic identity of the microscopic and megascopic forms found. Vast labors in the field, in the laboratory, the herbarium, and museum by a score or more of men were needed to complete, in the course of years, a reasonably accurate description of this formation.

The result of all this labor is the description of a *single individual*, one body of deposits. No laws can be derived from this individual. But laws are needed to understand its properties.

Take the most conspicuous property of these beds, the fine lamination that runs with mathematical accuracy through every microscopic section, in endless alternations of pairs of layers, measured in tenths of millimeters, one chiefly organic matter, the other largely inorganic. What does it mean?

Many possible explanations come to mind. The geologist, more than other men of science, must work with multiple hypotheses. For understanding, the geologist turns to limnology. One "law" of limnology suggests an explanation: the plancton of lakes reaches annually a relatively short peak dropping to a minimum for the rest of the year. The microscope shows that the organic matter of the laminae consists of plancton. Here is a possible answer. Another "law" of limnology[11] points to the same answer: the deposits at the bottoms of modern lakes in moist climates show similar alternations of organic (planctonic) and inorganic laminae.

The Green River beds represent part of the Eocene period. Radioactive minerals have furnished data which give a rough estimate of the length of the Eocene period. This can be compared with the length of time represented by the fraction of it comprised in the Green River shales, computed on the assumption that each pair of laminae records

[11]B. W. Perfiliew. "Das Gesetz der Periodizitat der Schlammbildung und die Tiefgewässer-Bohrung." Verh. Intern Verein. f. Limnologie, 1931, Vol. 5, pp. 298-306. (Known to the writer at present only through a review in Bot. Zentralbl., Vol. 164, p. 98, 1931, to which Dr. Th. Just called the writer's attention.)

one year. The figure found, 6,000,000 years, compares favorably. One more test suggests itself. The thickness of the pairs of laminae is variable. If they represent deposits of one year each, their varying thickness must somehow be connected with fluctuations of climate. A "law" of climatology proves useful: climatic variations proceed in complex curves in which definite cycles are recognizable. When plotted, the laminae of the Green River shale reveal the same cycles.

Thus each new investigation points in the same direction: we are getting nearer and nearer to a satisfactory understanding.[12]

This case is typical of geological work. The empirical laws formulated in the course of studies on living environments and processes—although not labeled as such—form the means of understanding the properties of an individual of stratigraphy—the Green River lake beds.

But there are other famous fossil lake beds—like those of Florissant in Colorado or of Oeningen in Switzerland and many others, little studied. As one by one they are described and analyzed, common properties will be recognized and formulated. There are already in existence interesting discussions of the "Criteria" for lacustrine sediments.

The field of structural geology represents a higher level of complexity in geologic studies. In certain belts the strata of the earth's crust lie deformed: broken by fractures, or crushed along shear zones, bent into folds and thrust one on top of the other along thrust planes. Here the difficulties in the way of study are multiplied. Even if the earth's crust were transparent and the actual features of the deformation could actually be seen to the depth of a mile or two, the mere task of recording, in intelligible manner, the three-dimensional pattern of a folded mountain chain would present great difficulties. With only the surface accessible to the eye and most of it concealed by vegetation and mantle rock, the unraveling of the structure of such regions as the Alps or the Scottish Highlands represents a herculean task, for the body as well as the mind.

While the anatomist can produce hundreds of sections with his microtome in a fraction of an afternoon, it takes years of topographic surveying and decades of geologic mapping, each man refining and correcting the observations of his predecessors, before a series of reasonably accurate cross-sections can be produced through such a region as the Swiss Alps or the folded Appalachians. Here again, then, the descriptions of individuals is still, by force of circumstances, the dominant occupation of the geologist.

Nevertheless, it is just in this field, that the search for typical patterns, for laws of deformations began early. Types of folds and patterns of fractures were early recognized and given names. The practical importance of many structural features in mining and prospecting led to a high development of the formal aspects of rock deformation. As early as 1878 Albert Heim's "Untersuchungen uber den Mechanismus

[12] I have quoted from a series of classical investigations by W. H. Bradley, of the U. S. Geological Survey. See especially, "The Varves and Climate of the Green River Epoch," U. S. G. S., Prof. Paper 158, 1929, pp. 87–110; "Origin and microfossils of the oil shale of the Green River Formation of Colorado and Utah," ibid., Prof. Paper 168, 1931, 58 pp. and 28 plates.

der Gebirgs Bildung" brought exemplary precise formulations of valid generalizations.

But understanding of the structural facts in terms of more basic laws has barely begun. For classical physics, proceeding along strictly inductive lines, had limited itself at first almost entirely to the simplest aspects of the deformation of bodies, which are below the elastic limit, where relatively simple equations can be tested by crucial experiment. Valiant attempts were made by geophysicists to attack the problems of rock deformation with the inadequate tools of the classical theory of elasticity. Papers were written that were learned but not convincing. Understanding could not be expected until physicists ventured forth from the abstract field of simplest cases into the realities of the world of bodies at large. This time industry has filled the gap with its practical demands, and a new empirical science, the physics of materials, has come into existence. Such basic properties as plasticity, strength, rigidity, brittleness are being studied exhaustively. Empirical laws are being cast into mathematical form. Fracture patterns and other forms of deformation are being studied and analyzed. In that way laws of behavior of materials are being formulated out of which ultimately will come a true insight into the nature of geological structures.

One phase of modern studies of granite massifs may serve as a concrete illustration. At the time when the merciless inflation of the after-war period crippled the activities of many German geologists by making distant traveling impossible, Dr. Hans Cloos at Breslau took a devoted body of students into the numerous granite quarries of the nearby mountains of Silesia and carried on systematic studies of the innumerable fractures that cut every granite body in nature.[13] Tens of thousands of readings giving the attitude in space of all important fracture surfaces observed were plotted graphically. Soon definite systems of fractures were recognized that run uniformly through a granite mass: fracture aligned at right angles to the strike; longitudinal fractures; conjugate shearing planes; and pinnate fractures along the contacts. This assemblage of fractures has since been found to be practically universally present in intrusive bodies of granite.[14] Their presence constitutes empirical laws of great value.

When these empirical laws had been established, Dr. Cloos undertook to supply the knowledge that was needed for understanding. In a series of ingenious laboratory experiments, he has attempted to reproduce the essential aspects of orogenic deformation. Reasoning in terms of factors of similitude, he used a mixture of water and clay for his experiments, a substance yielding to gravity and yet of such coherence as to fracture after the fashion of such solids as granite. When he showed his extraordinary results at the next International Congress,

[13]He carried out near his home investigations inspired in pre-war days, by his careful studies of beautifully exposed granite regions in the deserts of Southwest Africa.

[14]For a bibliography of papers by Cloos and his collaborators, see Robert Balk, "Primary Structure of Granite Massives," Bull. Geol. Soc. America, Vol. 36, 1925, pp. 695–696. (A larger paper by the same author, entitled "Structural Behavior of Igneous Rocks," will soon appear as one of the Memoirs of the Geological Societyof America.)

more than one geologist shrugged his shoulders: "What can one learn from wet mud about granite?"[15]

The highest degree of complexity is reached when the earth as a whole becomes the object of study—in what is now widely called geotectonics. Here it is not the details of structure of individual mountain ranges, but the pattern of folded mountains on the face of the earth as a whole that demands attention; not the relations of one plateau to another, but that of the continental platforms to each other and to the oceanic floors; not the events of volcanic outbursts in one region, but the connection that exists between belts of volcanism and belts of deformation; and so forth.

To the complexities of three-dimensional structure, the time element is added as the fourth dimension. The geologist's intricate and still very crude methods of relative timing must be used to determine whether epochs of folding are short, spasmodic events, or long drawn out processes; whether mountain folding takes place simultaneously in many parts of the earth followed by periods of quiet, or whether some folding has been going on somewhere on earth throughout geologic time; whether epochs of mountain folding coincide with times when continents became submerged by a rising sea level, or with times of emergence—and so forth.

In the four volumes of "The Face of the Earth," a work of rare compass, depth and beauty,[16] the product of thirty years,[17] Eduard Suess has laid the foundation for all such inductive studies concerning the deformation of the earth's crust. In this work the masterful picture of the then available knowledge of the structure of the whole face of the earth, covering over 2,700 pages, culminates in a few chapters of "Analyses" and Hypotheses" of only 138 pages[18] which grip by their moderation, the tentative and cautious tone of their interpretations. Fertilized by the fervent enthusiasm and the almost inexhaustible riches of this work, structural analysis has since been carried systematically into most parts of the world. The detailed literature on regional tectonics has grown beyond the grasp even of a genius. But the growing number of authentic summary accounts and of tectonic analyses of limited areas, on the other hand, are making accessible more and more the generalized results from many parts of the earth. From them gradually broader generalizations are being derived that hold good everywhere today and will stand the test of future observations, generalizations that are true "laws." A few such laws were established long ago, as, for

[15]The following papers deal with tektonic experiments of this type in general: H. Cloos. "Experimente zur inneren Tektonik." Centralbl. f. Min. Abt. B, 1928, pp. 609–621; "Künstliche Gebirge," I, Natur und Museum, 1929, pp. 225–243; II, ibid, 1930, pp. 258–269; "Zur experimentellen Tektonik," Naturwissenschaften, vol. 18, 1930, pp. 741–747; "Zur experimentellen Tektonik," Geol. Rundschau, 1930, pp. 353–367; "Zur experimentellen Tektonik," Naturwissenschaften, vol. 19, 1931, pp. 242.

[16]In his epilogue to the French Edition, Termier has called this work "bien un poëme, dans le sens complet de ce mot splendid qui veut dire création." "La Face de la Terre," vol. 3, pt. 4, 1918, p. 1713.

[17]Edward Suess, "Das Antlitz der Erde," Vol. I, 1883; Vol. II, 1888; Vol. III, pt. 1, 1901; Vol. III, pt. 2, 1909.

[18]In the English Edition of Sollas and Sollas.

instance, Elie de Beaumont's law of the episodic character of orogeneses (1829); Godwin-Austen's law of the tendency of posthumous folds to trend parallel with the lines of earlier folding (1856); Hall's law of the coincidence of belts of folding with belts of abnormally thick sediments (1859).

Ten years after Suess' death, Stille published his "Grundfragen der vergleichenden Tektonik."[19] The title of this remarkable work makes effective use of the expression "Comparative tectonics" and the text culminates in the formulation of a "law," Stille's "orogenes Zeitgesetz."[20] It is a broad generalization based on two properties of orogenic movements concerning their incidence in time. It is a general law of broad resolving power. The writer believes it to be valid. But geologists are by no means agreed that the two properties on which the law is based are really general and essential. Such a generalization can hardly be called more than an "opinion," until it can be shown to rest on a valid basis. On the whole we are not ready to formulate such broad laws. The first task is to crystallize knowledge concerning the observable properties of the structure of the earth's crust. Stille's book is primarily devoted to this task as far as the time element in orogenesis (and epeirogenesis) is concerned. The speaker has attempted to extend this work to other properties. On the strength of the convictions set forth in this address he spoke of them as "laws," *i. e.*, "specific laws" of crustal deformation, from which ultimately such "general laws" as Stille's will be derived. He might have listed his "specific laws" as "properties." He preferred the more challenging "law." The word he could not use, suggested to him more than once, was "theses." "Too much of the geotectonic literature of the past was concerned with the theses of men rather than with laws of nature."[21]

This, then, is the essence of all geologic work:

1. Not to be satisfied with the accumulation of facts alone, but to draw from them, at every opportunity, all possible generalizations. In other words, to search for the general properties, the "specific laws" in the reality with which we deal, and ultimately for such "general laws" as can be safely formulated.

2. To seek understanding of the empirical laws thus found by studying the findings of workers in the nearest level of complexity. For the geologist, that means stepping from the records of the past to the experiences of the present; from the properties of vast bodies to those of small units of the laboratory; from the complex systems of nature, to simpler systems capable of analysis. It means oceanography, limnology, hydrology, the physics of materials, the physical chemistry of silicate melts, and so forth, not simply elementary textbooks of chemistry or physics.

Neither of these two points is followed as widely as one should expect. As to the first, a multitude of facts is still published with little or no evidence of thought concerning their broader bearings. As to the second, uncontrolled speculation still too often takes the place of that

[19]Berlin, 1924 (Gebr. Borntraeger).

[20]Loc. cit., pp. 44–45.

[21]Walter H. Bucher, "The deformation of the earth's crust." Princeton, 1933, p. VII (Preface).

systematic searching for an adequate foundation for understanding which is needed. When we try to understand the Permian glaciation, we still invoke movements of the continents or of the poles (or both), instead of instigating that prolonged systematic research by competent meteorologists which alone can make sure that wide areal glaciation down to sea-level is impossible in equatorial latitudes; we use similar speculations when we speak of the existence during the geologic past of higher vegetation near the poles,[22] without having brought about investigations needed to decide if trees can grow where the night and day last half a year each; we demand vertical uplift of the continental shelves of nearly two miles to "explain" the submarine valleys before having placed the problem into the hands of experienced hydrologists familiar with the complex currents set up by the tides, and so forth.

Speculation that does not lead directly to further search for facts and laws is idle. The joy of understanding arises from reasoning, not from guessing; from the purposeful grouping of general facts, not from the mere play of the imagination.

Two things remain to be said. One refers to the human side of this task. The other points to the future outlook.

For the human side let us turn back once more to the boy-who-wanted-to-know in the museum. Let us assume that his enthusiasm held out through his high school years—we are optimists, you see. He has pushed through as fast as possible, impatient of any delay, to that field of science which at the time satisfied his fancy. He has become a geologist. The more he learns about the strata and structures, the less he is satisfied with the mere description of "facts." He turns to basic works on limnology, hydrology, physics of materials. And now he finds much that he cannot read. Not only a strange terminology, but the unfamiliar concepts and lines of reasoning of the basic sciences: physical chemistry, vector mathematics, statistics, etc. He wishes he had become a mathematician first, then a physicist, and then a chemist. He looks with envy upon those who work in the abstract fields of artificial simplicity, where knowledge is exact and reasoning rigorous. His own problems seem muddled, his own mind inadequate.

But when he seeks co-operation from the fortunate ones who are mathematicians and physicists, he makes a discovery. Just as he, in the typical case, at his stage of life cannot spend the energy and time necessary to acquire a working knowledge of the mental tools of the basic sciences, so the workers in the abstract sciences find the task too great to acquire the perspective over the intricacies of unabstracted reality without which creative work is impossible. Moreover, he who is accustomed to the "linear order of thought which is necessarily cultivated in . . . mathematics" finds it distasteful, if not difficult, to acquire "the habit of parallel . . " or "complex thought," as T. C. Chamberlin[23]

[22]Since this was written, coniferous wood of araucarian type has been reported, found together with leaf impressions of cycadophytes in the Upper Triassic or Jurassic florule associated with coal, which was collected in south latitude 86–58½, i. e., within 3 degrees of the South Pole. Wm. C. Darrah, "Antarctic fossil plants," Science, Vol. 83, 1936, pp. 390–391.

[23]T. C. Chamberlin, "The Method of Multiple Working Hypotheses," Jour. Geol., Vol. 39, 1931, p. 164. (Reprinted from the original in Jour. Geol., Vol. 5, 1897, pp. 837–848.)

once called it, in which a multitude of interrelated properties must be visualized and weighed as parts of an integral whole.

The recognition of this difference is wholesome. Every geologist needs such an experience to find the right pride in his work. The worker in the complex levels of science is the explorer, the man from the basic sciences the guide. One derives his significance from the other, and both derive the sense of dignity in their calling from the joint goal which is an ordered insight into complex reality.

As to the outlook for the future: I have spoken so far of two steps that enter into the mental process of the geologist. But there are really three:

First comes: *Analysis*, *"re-solving"* the complexity of geological reality into its constituent, essential elements of orderly recurrence, formulated as generalizations which we call "properties" or "specific laws."

Second: *Interpretation*, *"translating"* these "properties" or "specific laws" into the terms of the more "general laws" of the basic sciences. This constitutes "understanding."

The third is: *Synthesis*, *"putting together"* again, collecting in our consciousness the numerous threads of understanding into one adequate perspective of nature as we see it in its entirety.

"Analysis" is in full swing. "Interpretation, and with it "understanding," is growing, as laws are being formulated in the fields of investigation that lie between geology and the basic sciences.

But in the larger aspects of geology the final synthesis which is to give us a satisfying, logically consistent and coherent picture of the earth and the forces that have formed and are forming it, is a hope for the future. It will be brought about by the growth of a tendency which is taking form now. Analysis produces specialists; the growing need for synthesis will produce encylopedists. H. G. Wells put it this way: "The world, if all goes well with it, will consist very largely of specialists, who know every detail about and every relationship of something, and of people . . who will know everything in outline and in correlation. Specialism and encyclopedism are necessary correlatives."

Analysis and interpretation require the field and the laboratory. Synthesis is done in the philosopher's study. Most geologists, and for that matter most scientists at large, mistrust the man who studies not nature, but natural laws. His work looks like the boring and hoarding of the bookworm. Most scientists are still unaware of the difference between unimaginative compiling, the cataloguing of facts, and the creative power that is required for all true synthesis. Yet it is such synthesis alone which can make us fully aware of nature. For, to see the work of many in one perspective, to realize the common bond of natural law that permeates all our experiences of nature, means to realize the "internal harmony of the world" which, as Poincaré pointed out repeatedly,[24] is "The only true objective reality," the ultimate goal of all science.

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[24]H. Poincaré in "The Foundation of Science," The Science Press, 1929, e. g., pp. 207, 209.

ADDITIONS TO THE REVISED CATALOG OF OHIO VASCULAR PLANTS. IV[1]

JOHN H. SCHAFFNER

The past year has been one of great activity in the development of the Ohio State Herbarium. A number of very large collections have been received from various botanists and these have mostly been named and mounted. About 5,000 specimens have been mounted and added to the herbarium. This substantial growth of the collection was made possible through the assistance of six students working under N. Y. A.

Mr. Wm. C. Werner, of Painesville, who died in 1935, had expressed the desire that his private collection of plants should be presented to the State Herbarium. Accordingly, through the kindness of Mr. C. J. Werner, of Painesville, the entire Werner herbarium was sent to the Department of Botany and is being added to the State Herbarium. Wm. C. Werner was one of the early instructors in the Department of Botany of the Ohio State University and a co-author with Wm. A. Kellerman of the "Catalogue of Ohio Plants," published by the Ohio Geological Survey in 1893.

Dr. W. H. Camp has furnished a number of rare records obtained from specimens in the herbarium of the New York Botanical Garden. These are so designated unless there are also duplicates in the Ohio State Herbarium. Among the records given below are 37 species new to the Ohio list. One of these is a species new to science and three are records from other herbaria. Of the 35 newly listed species, 26 are apparently native and 11 are plants escaped from cultivation or accidental. The new species is represented by specimens collected in Jackson County by Pontius and Bartley. A slight beginning has been made in a revision of the nomenclature to bring it into agreement with the newly established International Rules. This revision will require a large amount of work and a considerable period of time for its accomplishments. In the meantime the American Code names will mostly be used until a complete change can be made to the new standard. This will be the most convenient procedure, especially since there is still no manual of the plants of the eastern United States available with the new nomenclature.

[1]Papers from the Department of Botany, The Ohio State University, No. 369.

3. *Botrychium neglectum* Wood. Wood's Grape-fern. Sugar Grove, Fairfield County. Glenn W. Blaydes and R. E. Shanks.
10.2. *Trichomanes boschianum* Sturm. Filmy-fern. Section 25, Laurel Twp., Hocking Co. Chas. R. Goslin.
12. *Polypodium polypodioides* (L.) Hitch. Gray Polypody. Columbia Twp., Meigs Co. Clyde H. Jones.
42a. *Polystichum acrostichoides schweinitzii* (Beck.) Small. Ten Mill Creek, near Sylvania Ave., 7 miles from city limits, Toledo. Lucas Co. Richard Wood.
47. *Pteretis nodulosa* (Mx.) Nieuwl. American Ostrich-fern. In moist low woods. West of Toledo along Ten Mile Creek, Lucas Co. Richard Wood.
60. *Equisetum silvaticum* L. Wood Horsetail. Edge of Clover Hill Bog. N. Bloomfield Twp., Trumbull Co. R. E. Shanks.
66.1. *Lycopodium tristachym* Pursh. Slender Trailing Clubmoss. Laurel Twp., Hocking Co. Gordon Van Buskirk.
68. *Selaginella rupestris* (L.) Spring. Rock Selaginella. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.
75.1. *Pinus nigra* Arn. Austrian Pine. Escaped from Cultivation at Geneva-on-the-Lake, Ashtabula Co. L. E. Hicks.
75.2. *Pinus silvestris* L. Scotch Pine. Escaped from cultivation. Geneva-on-the-Lake. Ashtabula Co. L. E. Hicks.
93. *Potamogeton pulcher* Tuck. Spotted Pondweed. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.
96. *Potamogeton heterophyllus* Schreb. Variant-leaf Pondweed. Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley. (N. Y. Bot. Garden).
98. *Potamogeton epihydrus* Raf. Nuttall's Pondweed. Salt Creek, Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.
106. *Potamogeton vaseyi* Robb. Vasey's Pondweed. Mosquito Creek, Howland Twp., Trumbull Co. Almon N. Rood and R. E. Shanks.
112.1. *Naias guadalupensis* (Spring.) Morong. Guadaloupe Naias. Washington Twp., Pickaway Co. Leslie L. Pontius and Floyd Bartley.
123. *Sparganium lucidum* Fern. & Eam. Shining-fruited Bur-reed. In alder swamp, Killbuck, Holmes Co., and Beach City, Stark Co. W. H. Camp and P. Zimpfer. Also swamp south of Delaware, Delaware Co. W. H. Camp.
135.1. *Lemna minima* Philippi. Least Duckweed. Benton Twp., Paulding Co. L. E. Hicks.
135.2. *Lemna perpusilla* Torr. Minute Duckweed. Washington Twp., Mercer Co. L. E. Hicks.
144.1. *Scirpus georgianus* Harper. Georgia Bulrush. Salem Twp., Meigs Co. Clyde H. Jones.
150. *Scirpus planifolius* Muhl. Flat-leaf Clubrush. Salt Creek Twp., Hocking Co. Mary Anna Drake.
159. *Eleocharis tenuis* (Willd.) Schultes. Slender Spike-rush. "Neotoma," Hocking Co. E. S. Thomas and R. B. Gordon.

163. *Eleocharis engelmanni* Steud. Engelmann's Spike-rush. Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.
166. *Stenophyllus capillaris* (L.) Britt. Hair-like Stenophyllus. Duncan Falls, Muskingum Co. L. E. Hicks and C. A. Dambach.
168.1. *Cyperus refractus* Engelm. Reflexed Cyperus, Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.
169.1. *Cyperus lancastriensis* Port. Lancaster Cyperus. Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley. Salisbury, Meigs Co. Clyde H. Jones.
169.2. *Cyperus torreyi* Britt. Torrey's Cyperus. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.
172. *Cyperus speciosus* Vahl. Michaux's Cyperus. Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.
190. *Scleria pauciflora* Muhl. Papillose Nut-rush. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.
205. *Carex aggregata* Mack. Glomerate Sedge. Pickaway Twp., Pickaway Co. Mary Anna Drake. Salem, Meigs Co. Clyde H. Jones.
210. *Carex brachyglossa* Mack. Yellow-fruited Sedge. Pickaway Twp., Pickaway Co. Mary Anna Drake.
230.1. *Carex projecta* Mack. Necklace Sedge. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.
292. *Carex caroliniana* Schw. Carolina Sedge. Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.
330. *Bromus japonicus* Thunb. Japanese Field Chess. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius. (New York Bot. Garden).
360.1. *Poa palustris* L. Fowl Blue-grass. In fields. Oberlin, Lorain Co. Coll. W. M. Dick. From F. O. Grover.
362.1. *Poa wolfii* Scribn. Wolf's Spear-grass. Adams Co. E. Lucy Braun. (In Braun Herb.)
369. *Eragrostis poaeoides* (L.) Beauv. Low Love-grass. (*Eragrostis eragrostis* (L.) Karst.). Lancaster, Fairfield Co. Robert and William Goslin.
375. *Sphenopholis pallens* (Spreng.) Scribn. Change name to Spenopholis intermedia (Rydb.) Rydb. Tall Wedge-grass.
384. *Danthonia compressa* Aust. Flattened Wilt-oat-grass. Salem, Meigs Co. Clyde H. Jones.
391. *Deschampsia flexuosa* (L.) Trin. Wavy Hair-grass. Berne Twp., Fairfield Co. Robert Goslin.
397. *Sporobolus asper* (Mx.) Kunth. Longleaf Rush-grass. Perry, Lake Co. F. J. Tyler.
400.1. *Calamagrostis insperata* Swallen. From the collection from which the type specimen was obtained. Ofer Hollow, Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.
416. *Muhlenbergia sobolifera* (Muhl.) Trin. Rock Muhlenbergia. Green Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.
430. *Aristida purpurascens* Poir. Purplish Triple-awn-grass. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.

438. *Lolium multiforum* Lam. Awned Darnel. Liberty Twp., Highland Co. Katie M. Roads.
447. *Elymus striatus* Willd. Slender Wild-rye. Yellow Springs, Greene Co. Delzie Demaree.
456.2. *Gymnopogon ambiguus* (Mx.) B. S. P. Broad-leaf Naked Beardgrass. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.
475. *Panicum perlongum* Nash. Long-stalked Panic-grass. Lynx, Adams Co. R. B. Gordon and A. R. Harper.
483.1. *Panicum yadkinense* Ashe. Spotted-sheath Panic-grass. In bottoms, Shawnee State Forest, Scioto Co. Delzie Demaree.
484. *Panicum boreale* Nash. Northern Panic-grass. Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley. (N. Y. Bot. Garden.)
486.1. *Panicum barbulatum* Mx. Barbed Panic-grass. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.
490. *Panicum tsugetorum* Nash. Hemlock Panic-grass. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius. (N. Y. Bot. Garden).
498a. *Panicum boscii molle* (Vasey) Hitchc & Ch. Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley. (N. Y. Bot. Garden).
499. *Leptoloma cognatum* (Schultes) Chase. Fall Witch-grass. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.
500. *Syntherisma filiforme* (L.) Nash. Slender Crab-grass. Liberty Twp. Jackson Co. Leslie L. Pontius and Floyd Bartley.
504. *Echinochloa frumentacea* (Roxb.) Link. Billion-dollar-grass. Along the road in southwestern Fayette Co. Katie M. Roads.
505.2. *Paspalum pubiflorum glabrum* Vasey. (*P. laeviglume* Scribn.). Smooth-glumed Paspalum. Pickaway Twp., Pickaway Co. Leslie L. Pontius and Floyd Bartley.
505.3. *Paspalum laeve* Mx. Field Paspalum. Letart Twp., Meigs Co. Clyde H. Jones.
508. *Paspalum setaceum* Mx. Slender Paspalum. Liberty Twp., Highland Co. Katie M. Roads.
508.2. *Paspalum longipedunculatum* LeC. Long-stalked Paspalum. Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.
514.1. *Holcus sudanensis* Bailey. Sudan-grass. Escaped to low pasture land. Glenford, Perry Co. L. E. Hicks and C. A. Dambach.
517. *Miscanthus sinensis* Anderss. Chinese Plume-grass. Salisbury, Meigs Co. Clyde H. Jones.
520. *Andropogon elliottii* Chapm. Elliott's Beard-grass. Salem, Meigs Co. Clyde H. Jones.
525. *Yucca filamentosa* L. Adam's-needle. Salem, Meigs Co. Clyde H. Jones.
575. *Clintonia umbellulata* (Mx.) Torr. White Clintonia. White's Gulch, Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.

579. *Smilax ecirrhata* (Engelm.) Wats. Upright Smilax. Killbuck, Holmes Co. Sugar Creek Twp., Stark Co. W. H. Camp.

597.1. *Juncus interior* Wieg. Inland Rush. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.

606. *Juncus brachycarpus* Engelm. Short-fruited Rush. Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.

611. *Juncoides carolinae* (Wats.) Ktz. Hairy Wood-rush. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.

613. *Juncoides bulbosum* (Wood) Small. Bulb-bearing Wood-rush. Black Hand, Licking Co. E. R. Shilling, Jr. "Neotoma," Hocking Co. E. S. Thomas and Robert B. Gordon.

614. *Xyris torta* Smith (=*X. flexuosa* Muhl.) Slender Yellow-eyed-grass. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.

615. *Eriocaulon septangulare* With. Seven-angled Pipewort. Lake Brady, Portage Co. E. R. Shilling Jr.

631.1. *Iris chamaeiris* Bertol. Evergreen Dwarf Garden Iris. Escaped from cultivation in Columbus, Franklin Co. Adolph E. Waller and John H. Schaffner.

643. *Gymnadeniopsis clavellata* (Mx.) Rydb. Green Wood-orchis. Nile Twp., Scioto Co. F. B. Chapman.

657. *Ibidium praecox* (Walt.) House. Grass-leaf Lady's-tresses. Nile Twp., Scioto Co. F. B. Chapman. Salem, Meigs Co. Clyde H. Jones.

678. *Magnolia acuminate* L. Cucumber Magnolia. Large tree in forest near Westerville, Franklin Co. W. H. Camp.

682. *Ranunculus micranthus* Nutt. Rock Crowfoot. Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.

695. *Ranunculus delphinifolius* Torr. Yellow Water Crowfoot. Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.

787. *Thlaspi perfoliatum* L. Perfoliate Penny-cress. Hillsboro, Highland Co. Katie M. Roads.

794. *Cheirinia repanda* (L.) Link. Repand Cheirinia. Berne Twp., Fairfield Co. Robert Goslin and Wm. Goslin.

822. *Cardamine arenicola* Britt. Sand Bitter-cress. Pickaway Twp., Pickaway Co. Floyd Bartley and Leslie L. Pontius.

867. *Linum striatum* Walt. Ridged Flax. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius (N. Y. Botanic Garden.)

876. *Zanthoxylum americanum* Mill. Prickly-ash. Bloomfield Twp., Trumbull Co. R. E. Shanks.

882.1. *Polygala curtissii* Gr. Curtiss' Milkwort. Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.

883. *Polygala incarnata* L. Pink Milkwort. Nile Twp., Scioto Co. F. B. Chapman.

885. *Polygala ambigua* Nutt. Loose-spiked Milkwort. Manchester Twp., Morgan Co. W. Paul Haskins.

943. *Hypericum boreale* (Britt.) Bickn. Northern St. John's-wort. Sugar Grove, Fairfield Co. George A. Heffner and Glenn W. Blaydes.

987. *Viola fimbriatula* Sm. Ovate-leaf Violet. Adams Twp., Lucas Co. Louis W. Campbell. Vincent, Washington Co. C. F. Walker and J. W. Sites.

1035. *Dianthus armeria* L. Deptford Pink. Near Delaware, Delaware Co., and North of Sugar Grove, Fairfield Co. Glenn W. Blaydes.

ELATINACEAE. Water-wort Family

1041.1. *Elatine brachysperma* Gr. Short-seeded Water-wort. Edge of small pond. Pickaway Twp., Pickaway Co. Floyd Bartley and Leslie L. Pontius.

1050. *Celosia cristata* L. Cock's-comb. long Olentangy R., Columbus, Franklin Co. Nicholas H. Alter.

1089.1. *Centunculus minimus* L. Chaffweed. Liberty Twp., Jackson Co., and Pickaway Twp., Pickaway Co. Floyd Bartley and Leslie L. Pontius.

1103. *Pleuropterus zuccarinii* Small. Japanese Knotweed. Yellow Springs, Greene Co. Delzie Demaree.

1131. *Geum flavum* (Port.) Bickn. Cream-colored Avens. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.

1188. *Prunus mahaleb* L. Mahaleb Cherry. Margin of Woods. Rock House State Park. Hocking Co., and John Bryan State Park, Greene Co. Delzie Demaree.

1195. *Prunus nigra* Ait. Canada Plum. Oregon Twp., Lucas Co. Collected by Max Shephurst. Specimens also in the herbarium from Hancock, Shelby, and Clermont Cos. Determined by W. H. Camp from material originally labeled otherwise.

1204. *Aronia atropurpurea* Britt. Purple Chokeberry. Ganges, Richland Co. R. T. Wareham.

1206.2. *Amelanchier spicata* (Lam.) C. Koch. Low June-berry. On rocky bank. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.

1207. *Amelanchier sanguinea* (Pursh.) DC. Roundleaf Juneberry. Madison Twp., Richland Co. Fred W. Wagner.

1213.1. *Crataegus neofluviatilis* Ashe. New River Hawthorn. Reported from Northwestern Ohio.

1265. *Astragalus carolinianus* L. Carolina Milk-vetch. Union Twp., Scioto Co. Conrad Roth.

1288.1. *Lespedeza formosa* Koehne. (L. sieboldi Miq.) Purple Bush-clover. From Japan. Escaped from cultivation. Zanesville, Muskingum Co. Lawrence E. Hicks.

1293. *Lespedeza stuvei* Nutt. Stuve's Bush-clover. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.

1314. *Lathyrus latifolius* L. Everlasting Pea. Blanchester, Clinton Co. Katie M. Roads.

1326. *Strophostyles pauciflora* (Benth.) Wats. Small Wild Bean. Along R. R. Conesville, Muskingum Co. L. E. Hicks and C. A. Dambach.

1328.1. *Sedum sarmentosum* Bunge. Creeping Stonecrop. A persistent escape and very prolific. From China. In a vacant lot. Hillsboro, Highland Co. Katie M. Roads.

1345.1. *Lythrum hyssopifolia* L. Hyssop Loose-strife. Washington Twp., Pickaway Co. Floyd Bartley and Leslie L. Pontius.

1349. *Rhexia virginica* L. Virginia Meadow-beauty. Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.

1361. *Vitis cinerea* Engelm. Ashy Grape. Salem, Meigs Co. Clyde H. Jones.

1427. *Quercus marilandica* Muench. Black-Jack (Oak.) Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.

1432.1. *Quercus schneckii* Britt. Schneck's Oak. Originally identified as Q. texana Bulk. Franklin Co., Columbus, W. A. Kellerman, Georgesville, Wm. C. Werner. Valley Twp., Scioto Co. Conrad Roth.

1436.1. *Corylus rostrata* Ait. Beaked Hazelnut. Adams Co. E. Lucy Braun.

1448.1. *Carya ovalis* Sarg. (Hicoria). Oval Pignut (Hickory). Ft. Ancient State Park, Oregonia, Warren Co. Delzie Demaree.

1468. *Salix pentandra* L. Bayleaf Willow. In low ground. John Bryan State Park, Yellow Springs, Greene Co. Delzie Demaree.

1482a. *Salix humilis tristis* (Ait.) Griggs. Upper Rocky Fork, Scioto Co. Delzie Demaree.

1483.1. *Tetragonia expansa* Murr. New-Zealand-spinach. Spontaneous and growing as a weed in flower beds. Liberty Twp., Highland Co. Katie M. Roads.

1497. *Grossularia reclinata* (L.) Mill. Garden Gooseberry. Escaped near Painesville, Lake Co. Wm. C. Werner.

1523. *Myriophyllum heterophyllum* Mx. Variant-leaf Water-milfoil. Mosquito Creek, Howland Twp., Trumbull Co. Almon N. Rood and R. E. Shanks. In a recently-made fish pond. Hillsboro, Highland Co. Katie M. Roads.

1528. *Cucurbita pepo* L. Pumpkin. A numebr of plants growing wild in waste ground. North of Columbus, Franklin Co. John H. Schaffner.

1555. *Hypopitys americana* (DC). Small. Smooth Pinesap. Nile Twp., Scioto Co. F. B. Chapman.

1580. *Phlox stolonifera* Sims. Creeping Phlox. Columbiana Twp., Meigs Co. C. H. Jones.

1595. *Cuscuta epithymum* Murr. Clover Dodder. Salem, Meigs Co. Clyde H. Jones.

1613.1. *Ligustrum obtusifolium* S. & Z. Blunt-leaf Privet. Escaped from cultivation. From Japan. In the edge of a locust thicket, Marshall Twp., Highland Co. Katie M. Roads.

1616.1. *Fraxinus profunda* Bush. Pumpkin Ash. In the Illinoian Till Plain of S. W. Ohio. North of Ft. Ancient, Warren Co. Also in Brown Co. E. Lucy Braun Herbarium.

1641. *Asclepiodora viridis* (Walt.) Gr. Oblong-leaf Green Milkweed. Salem, Meigs Co. Clyde H. Jones.

1650. *Asclepias variegata* L. White Milkweed. Nile Twp., Scioto Co. Conrad Roth.

1657. *Vincetoxicum obliquum* (Jacq.) Britt. Large-flowered Vincetoxicum. Columbia Twp., Meigs Co. C. H. Jones.

1660.1. *Petunia axillaris* (Lam.) B. S. P. White Petunia. Escaped from cultivation. From S. Amer. Along Muskingum R. near Conesville, Coshocton Co. L. E. Hicks and C. A. Dambach.

1666.1. *Physalis subglabrata* Mack. & Bush. Smooth Groundcherry. Mentor, Lake Co. Wm. C. Werner. Specimens also in the herbarium from Lorain, Franklin, Ross, and Clermont Cos.

1673. *Physalis pruinosa* L. Tall Hairy Groundcherry. Buchanan, Pike Co. Katie M. Roads.

1687. *Penstemon pallidus* Small. Downy White Beard-tongue. Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.

1703. *Ilysanthes inaequalis* (Walt.) Penn. (New Name Lindernia inaequalis (Walt.) Penn.) Long-stalked False Pimpernel. Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.

1722. *Veronica anagallis-aquatica* L. Water Speedwell. Columbus, Franklin Co. E. T. Wherry and F. W. Pennell.

1737.1. *Linaria dalmatica* (L.) Mill. Dalmatian Toad-flax. In an alfalfa field. North of Worthington, Franklin Co. From Macedonia, Europe. Clyde H. Jones.

1742. *Kickxia elatine* (L.) Dum. Sharp-pointed Cancerwort. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.

1743. *Cymbalaria cymbalaria* (L.) Wettst. Kenilworth-ivy. Berne Twp., Fairfield Co. Robert Goslin.

1786.1. *Vitex negundo incisa* Clarke. Escaped near W. Alexandria, Preble Co. From Eastern Asia. L. E. Hicks.

1824. *Lycopus uniflorus* Mx. Northern Water-hoarhound. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.

1844. *Meehania cordata* (Nutt.) Britt. Meehania. Salem, Meigs Co. Clyde H. Jones.

1878. *Plantago arenaria* W. & K. Sand Plantain. Along R. R., Columbus, Franklin Co. Arthur R. Harper.

1923. *Foeniculum foeniculum* (L.) Karst. Fennel. Liberty Twp., Highland Co. Katie M. Roads.

1962. *Galium mollugo* L. White Bedstraw. Blue Creek, Adams Co. R. B. Gordon and A. R. Harper.

1994. *Lonicera sempervirens* L. Trumpet Honeysuckle. Salem, Meigs Co. Clyde H. Jones.

2053. *Helianthus mollis* Lam. Hairy Sunflower. North of Pomeroy, Meigs Co. Conrad Roth, Roosevelt State Park, Nile Twp., Scioto Co. F. B. Chapman.

2070. *Cosmos bipinnatus* Cav. Cosmos. Blanchester, Clinton Co., and Southwestern Fayette Co. Katie M. Roads.

2086. *Coreopsis tinctoria* Nutt. Golden Tickseed, Berne Twp., Fairfield Co. Robert Goslin.

2089. *Chrysogonum vitginianum* L. Chrysogonum. Dunham Twp., Washington Co. C. F. Walker and J. W. Sites.

2094. *Silphium laciniatum* L. Compass-plant (Rosin-weed). Along railway track, North Columbus. Doubtfully native. A. R. Harper. Same place John H. Schaffner.

2110. *Anaphalis margaritacea* (L.) Benth. & Hook Pearly Everlasting. Zanesville, Muskingum Co. C. A. Dambach and L. E. Hicks.

2117. *Chrysopsis graminifolia* (Mx.) Ell. Grass-leaf Golden-aster. Green Twp., Adams Co. Conrad Roth.

2131.1. *Solidago altissima* L. Tall Goldenrod. Perry, Lake Co. F. J. Tyler. Chester, Meigs Co. Clyde H. Jones.

2143. *Bellis perennis* L. European Daisy. On old lawns. Bloomfield Center, Trumbull Co. R. E. Shanks.

2144.1. *Boltonia latisquama* Gr. Broad-sealed Boltonia. Escaped at Perry, Lake Co. Seeds itself in waste ground near nurseries. From the Missouri-Oklahoma region. F. J. Tyler.

2165. *Aster concinnus* Willd. Narrow-leaf Smooth Aster. Olive, Meigs Co. Clyde H. Jones.

2183. *Leptilon divaricatum* (Mx.) Raf. Low Horseweed. Liberty Twp., Wood Co. Helene Miller.

2191.1. *Eupatorium pubescens* Muhl. Hairy Thoroughwort. Kunkle's Hollow, Hocking Co. R. B. Gordon.

2198.1. *Kuhnia glutinosa* Ell. Glutinous False Boneset. Georgesville, Franklin Co. Wm. C. Werner (In N. Y. Bot. Garden). Pickaway Twp., Pickaway Co. Floyd Bartley and Leslie L. Pontius.

2201.1. *Lacinaria shortii* Alex. Short's Blazing-star. Specimen from "Ohio" in N. Y. Bot. Garden collected in 1842. Probably collected in southern Ohio. Reported by W. H. Camp.

2206. *Vernonia missurica* Raf. Missouri Ironweed. Salem, Meigs Co. Clyde H. Jones.

2223. *Artemisia ludoviciana* Nutt. Western Mugwort. A roadside weed on the Gage farm. Painesville, Lake Co. F. J. Tyler. Zanesville, Muskingum Co. L. E. Hicks and C. A. Dambach.

2233. *Senecio pauperculus* Mx. Balsam Squaw-weed. Columbia, Meigs Co. Clyde H. Jones.

2234. *Senecio plattensis* Nutt. Prairie Squaw-weed. Waterville Twp., Lucas Co. Louis W. Campbell.

2254. *Onopordon acanthium* L. Scotch Thistle. New Paris, Preble Co. Paul J. Hanes.

2255. *Centaurea jacea* L. Brown Star-thistle. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.

2259. *Centaurea maculosa* Lam. Spotted Star-thistle. Salem, Meigs Co. Clyde H. Jones.

THE ALIMENTARY TRACT OF THE MARGINED BLISTER BEETLE, EPICAUTA CINEREA MARGINATA FAB. (COLEOPTERA—MELOIDAE)[1]

RAY THOMAS EVERLY
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During the Fall of 1927, while engaged on field work for the United States Department of Agriculture in Meigs and Monroe counties in southeastern Ohio, several heavy infestations of adult blister beetles of the species *Epicauta cinerea* Forst. variety *marginata* Fab., (the margined blister beetle), were observed upon the flowering spikes of ragweed, (*Ambrosia elatior* L.), and several hundred specimens were collected. These were fixed in Kahle's solution and stored in 70% alcohol.

Sections were made of the internal organs and stained with haemalum and fast green. Repeated trials proved that over-staining in haemalum, 2 to 3 hours, and very short staining in the fast green, 8 to 10 seconds, gave the best differentiation of the tissues and cells. All sections were cut 10 microns in thickness.

The investigation was carried on under the direction of Dr. C. H. Kennedy, to whom appreciation is expressed, and to fellow students in the graduate department of Entomology, in particular to Mr. R. H. Davidson, Mr. P. E. Schaefer, and Mr. F. B. Whittington, and to Mrs. Laura Wadsworth Everly for assistance with the manuscript.

THE GROSS ANATOMY OF THE DIGESTIVE TRACT

The alimentary tract in general, is similar to that found in other coleopterous insects. It consists of three main divisions, the fore-intestine, (stomodeum), the mid-intestine, (mesenteron), and the hind-intestine, (proctodeum), and is approximately one and one-third times the body length, (Plate I, Fig. 3). The fore and hind-intestines are ectodermal in origin, whereas the mid-intestine originates from the mesoderm.

THE FORE-INTESTINE

The fore-intestine occupies approximately one-fourth the alimentary tract and consists of the oesophagus, a long narrow tube showing but little variation in diameter until just before reaching the mid-intestine,

[1]Thesis presented as partial fulfillment of the requirements for the degree of Master of Science.

where it abruptly widens into the gizzard. There is no external constriction at the oesophageal valve. Sections of the gizzard show very characteristic foldings of the intima, (INT, Plate I, Fig. 1). The oesophageal valve is definitely a part of the fore-intestine, as a tension placed upon the alimentary tract separates the fore and mid-intestines, the oesophageal valve remaining attached to the former. A gross examination discloses this valve to consist of four finger-like projections, which extend into the mid-intestine about one-fifth its length. These projections are attached at the base and are free the greater portion of their length. They appear to be of similar shape and size, (Plate II, Fig. 4). The outer edges are heavily chitinized on the basal third and gradually less so to the apex. This chitin is pigmented with a yellow color, which is retained in sections and does not stain.

THE MID-INTESTINE

The mid-intestine occupies about one-fourth the entire alimentary tract. It is a large and broad organ, filling the greater portion of the abdomen. Externally it appears folded and covered with minute papillae, the latter being the infolding of the epithelial tissue, which is apparent through the thin translucent connective tissue surrounding the entire mid-intestine.

THE HIND-INTESTINE

The mid-intestine narrows more or less abruptly into the hind-intestine. At this point the six malpighian tubules first enter the tract. Posterior to their point of entrance, the ileum turns abruptly anteriorly. Along this curvature striations or ridges appear externally, which are apparently due to the peculiar arrangement of the circular muscles and the heavier longitudinal muscles at this point, (C M, L M, Plate III, Fig. 8). This part of the intestine appears dark and heavy walled, attributable to the heavy musculature of this part of the hind-intestine. The ileum proceeds anteriorly to about the midpoint of the mid-intestine, at which point the six malpighian tubules enter the tract the second time. At this point of entrance they do not penetrate into the lumen, but remain just beneath the connective tissue. Here the ileum once more turns and then proceeds posteriorly, gradually widening into the colon, and then, more or less abruptly, into the short, broad, bulbous-appearing rectum. The hind-intestine occupies about one-half of the alimentary tract.

THE HISTOLOGY OF THE ALIMENTARY TRACT

THE FORE-INTESTINE

A histological examination of the fore-intestine shows it to consist of the following tissues, the connective tissue, (often misnamed the peritoneal membrane), the circular muscles, the longitudinal muscles, the hypodermal cells, and the intima, (Plate I, Figs. 1 and 2); Plate II, Fig. 5).

The connective tissue is a very thin membranous-appearing layer of

cells, entirely surrounding the alimentary tract and its appendages. In the fore-intestine it retains its membranous appearance the entire length.

Immediately within the connective tissue is the layer of circular muscles, consisting of a relatively few fibers in the anterior portion of the oesophagus, (C M, Plate I, Fig. 2), to a layer four or five fibers in thickness around the gizzard, (C M, Plate I, Fig. 1), and the oesophageal valve, (C M, Plate II, Fig. 5).

Just within the layer of circular muscles are the longitudinal muscles, which nearly fill the folds of the intima in the anterior portion of the fore-intestine, (L M, Plate I, Figs. 1 and 2), and apparently are entirely absent at the oesophageal valve, (L M, Plate II, Fig. 5). These muscle fibers are relatively short.

At the base of the intima and lying next to the longitudinal muscles is the hypodermal tissue. In the fore-intestine these cells are relatively small, flattened, brick-like in appearance. Between this tissue and the muscle tissues is the basement membrane, which, however, could not be demonstrated in the fore-intestine, either in longitudinal or cross sections.

The intima, which lines the lumen of the fore-intestine, is secreted by the hypodermal cells and is homologous with the chitin of the body wall. However, it does not appear to be pigmented, with the exception of the oesophageal valve, and stains with fast green. The outer layer of primary intima stains a much deeper color than the inner or secondary intima. However there is no definite line of demarcation between the two layers, the color gradually increasing in intensity as the surface is approached. At the base of the oesophageal valve, the intimal layer, just prior to its end, shows projections of the base of the hypodermal cells into the secondary layer, (HYP, INT, Plate II, Fig. 5). Here the hypodermal cells are elongated and slender, projecting into the open space within the finger-like projection of the valve itself.

In the anterior portion of the oesophagus, the folds of the intima projecting into the lumen, are irregular in size, shape, and number, (INT, Plate I, Fig. 2). However in the gizzard, just anterior to the oesophageal valve, these folds assume a more or less definite and regular arrangement and shape, (INT, Plate I, Fig. 1). This consists of four folds, mushroom-shaped in cross section, of thick, heavy intima. Arising just above the base of these folds are two shorter folds, finger-like in cross section, one on each side. Between the large mushroom-shaped folds is one long finger-like fold.

A longitudinal section of the fore-intestine demonstrates a ringed or ridged characteristic structure of the surface of the intima of the posterior portion of the oesophagus and of the gizzard. From the summits of these ridges, spines of chitinous material project in a curved direction, mesad and caudad, into the lumen. These spines do not stain and are about equal in length to the thickness of the intima. As the oesophageal valve is approached, these spines become rapidly shorter, appearing as tooth-like ridges upon the throat of the valve and rapidly becoming obsolescent posteriorly, (INT, Plate II, Fig. 5). These spines appear also in the hind-intestine, immediately posterior to the entrance of the malpighian tubules into the lumen of the intestine, but they do not

occupy as extended an area, also the ringed character of the intima is entirely lacking in the hind-intestine.

Between the fore and mid-intestines, enclosed within the connective tissue, is a wedge-shaped collar of tissue, (F T, Plate II, Fig. 5). This tissue stains a deep green and the cell walls cannot be demonstrated. It appears filled with small globules of oil and is possibly a fatty tissue. It entirely surrounds the oesophageal valve.

THE MID-INTESTINE

The mid-intestine occupies the greater portion of the abdomen and in its entirety is of uniform appearance, both externally and histologically. Circular and longitudinal muscles may be present, but in very small numbers, and could not be identified in most of the sections. Surrounding the mid-intestine is the connective tissue, which is contiguous with that of both the fore and hind-intestines. The tissues within the connective tissue is chiefly composed of epithelial cells, whose function is the excretion of digestive fluids. This epithelial layer of cells is invaginated to form large folds of epithelial tissue, which project well into the lumen of the mid-intestine. At intervals along the basement membrane are located ovoid, dark-stained masses, which are probably the nidi from which the epithelial cells arise. (C T, EPI, NI, Plate I, Fig. 5; Plate III, Fig. 8). These epithelial cells are formed in definite groups, surrounded by a membrane. Around the inner or mesal edge of the epithelial tissue is another membrane, which is probably the peritrophic membrane or at least functions in that capacity. It follows closely the foldings of the epithelial tissue, and its origin could not be determined.

THE HIND-INTESTINE

At the posterior end of the mid-intestine, just prior to the first entrance of the malpighian tubules, is a layer of intima and hypodermal cells which have a "fluffy" appearance and project slightly into the lumen of the mid-intestine. This is the only indication of a pyloric valve. Here as in the finger-like projections of the oesophageal valve, the hypodermal cells are much elongated and slender, and they have projecting attachments to the secondary intima which stain a very deep green. The basement membrane is in decided evidence, and there are a few fibers of circular muscles present about the valve, (INT, HYP, C M, Plate III, Fig. 8).

The first point of entrance of the malpighian tubules is taken as the point of demarcation between the mid and hind-intestine, which is supported histologically by a decided differentiation between the tissues of each of the parts of the tract. The connective tissue, which is present as a thin membrane, anterior and posterior to this point, becomes much thickened, although definite cell separations and nuclei could not be demonstrated, and separates from the other enclosed tissues to form a separate surrounding envelope about the entrance of the tubules, (C T, Plate III, Fig. 6). Anteriorly from this point, along the tubules, the connective tissue once more becomes intimately associated with the tubules, (C T, Plate III, Fig. 7). Any extension of the intima of the hind-intestine and pyloric valve into the malpighian tubules could not

be shown. The extent and paths of the tubules in the body cavity could not be determined, as they became very brittle in the preserved material and were intertwined with the other tissues in the abdomen of the insect. However, they are evidently very extensive, as the body cavity was quite filled with the tubules.

Immediately posterior to the entrance of the tubules is the hind-intestine. The tissues of this part of the alimentary tract are very similar in appearance and location to those of the fore-intestine, substantiating the evidence that these portions of the alimentary tract are both of ectodermal origin, the chief difference noted being the relationship between the muscle tissues. In the fore-intestine the circular muscles entirely surrounded the longitudinal muscles, whereas in the hind-intestine, the longitudinal muscles are isolated strands of fibers located at more or less regular intervals outside the circular muscles.

The distal ends of the malpighian tubules re-enter the tract at a point about midway along the ileum. They do not penetrate into the lumen but remain just beneath the connective tissue that surrounds the digestive tract. Here they begin a series of convolutions and eventually form a complete sheath about the hind portion of the ileum and the entire colon, and fore-part of the rectum, (M T, Plate III, Fig. 9; Plate IV, Fig. 10). It was not determined whether the tubules divide, however they become much smaller, both the tubes and the cells composing them, and, either the tubes divide, or, they dwindle in size due to the convolutions, which occur in a very short distance, to form a complete layer of tubules about the tract. Just prior to the anus, the tubules end blindly in the space between the outer sheath of connective tissue and the circular muscles.

The longitudinal muscles are very small and few in number, and are located outside the circular muscles at points about equidistant about the digestive tract. They are most numerous just posterior to the pyloric valve, but can scarcely be demonstrated in the rectum. The longitudinal muscle fibers lie in constrictions of the circular muscles in each part of the hind-intestine although in the rectum these constrictions are scarcely evident.

The entire hind-intestine, with the exception of the posterior portion of the rectum, shows a well-developed circular muscle system. These muscles first appear just prior to the first entrance of malpighian tubules, (C M, M T, Plate III, Fig. 8), and surround the pyloric valve. In the forepart of the ileum they are a thick heavy layer of tissue and are "tied-in" at six points to the hypodermal layer. This same "Tieing-in" is apparent throughout the entire hind-intestine, but less noticeably so in the posterior portion of the rectum, (C M, Plate IV, Fig. 11). At each of these points the hypodermal layer and intima are in close association with the muscle layer. As the posterior portion of the ileum is approached, the thickness of the circular muscle tissue decreases notably. This decrease continues until in the colon only two or three very elongate fibers remain, and in the forepart of the rectum, only one fiber surrounds each portion of the tract, (C M, Plate IV, Fig. 10). From this point there is a sudden increase in the fibers to just prior to the anus, where the circular muscle tissue becomes many fibers thick, (C M, Plate IV, Fig. 11).

In contrast to the fore-intestine, the basement membrane in the hind-intestine is very evident its entire length.

The hypodermal layer of tissue is much more in evidence in this portion of the alimentary tract than in the fore-intestine. Here the cells are much larger and nearly square in outline. At the point where the hypodermal cells appear, just prior to the first entrance of the malpighian tubules, (HYP, Plate III, Fig. 8), the cells are much elongated and have dark-staining attachments to the secondary intima, as was noted in the oesophageal valve. In the ileum the cells of this tissue are much smaller and increase in size as the posterior part of the hind-intestine is approached, (HYP, Plate III, Fig. 9; Plate IV, Figs. 10 and 11). As these cells secrete the intima, they are very closely associated with it and lie in folds projecting into the lumen of the tube.

As stated previously, the intima shows the spiny character exhibited in the oesophagus and gizzard of the fore-intestine, but here the area is not as extended, (INT, Plate III, Fig. 8). There is no ringing or striation of the intima in the hind-intestine. The intima at the pyloric valve is of a "fluffy" appearance, which character is maintained for a short distance posteriorly. It is very thick at this point, gradually becoming less so as the narrower part of the ileum, (INT, Plate III, Fig. 9), is approached, and then becoming increasingly thick toward the rectum, (INT, Plate IV, Figs. 10 and 11). In the colon the intima is quite thick, and in the forepart of the rectum lies in pad-like arrangement, (INT, Plate IV, Fig. 10). There are six of these pads, whose delineations, however are shown only by the attachment of the circular muscle fibers and the thinning of the intima at these points. In the posterior portion of the rectum, the intima projects into the lumen in numerous folds, which nearly fill the lumen of the rectum, (INT, Plate IV, Fig. 11.) Anterior to the rectal pads, the folds of the intima nearly fill the lumen of the tube, becoming gradually less elongate until a short distance posterior to the pyloric valve, where they become more nearly as in the anterior portion of the rectum.

SUMMARY

This paper is a study of the morphology and histology of the alimentary tract of the blister beetle, *Epicauta cinerea* Forst., variety *marginata* Fab., collected in southeastern Ohio.

The fore-intestine consists of the oseophagus, gizzard, and oesophageal valve. The latter is highly developed, consisting of four finger-like projections, which extend into the mid-intestine about one-fifth its length.

The mid-intestine lacks any well-developed muscle tissues. The epithelial tissue is invaginated to form folds, which project well into the lumen of the intestine. This tissue possibly forms the peritropic membrane.

Just prior to the entrance of the malpighian tubules, there is a ring of circular muscles. At this point the intima and

hypodermal cells project slightly into the lumen of the tract. This is the only indication of a pyloric valve.

The hind-intestine consists of the ileum, the colon, and the rectum. The circular muscles are well-developed in the ileum, and posterior portion of the rectum. In the colon and anterior portion of the rectum, they consist of only one or two strands. The longitudinal muscles are few in number, and arranged in groups of six, approximately equi-distant about the circular muscles, which exhibit a "tieing-in" at these points.

The malpighian tubules are six in number and enter the tract at two points, just posterior to the pyloric valve, where they penetrate into the lumen of the alimentary tract, and midway of the ileum, where they remain beneath the connective tissue, and through increasing convolutions and decreasing size form a sheath of small tubules about the posterior portion of the hind-intestine.

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ABBREVIATIONS USED ON PLATES

B M—Basement Membrane.
C M—Circular Muscles.
COL—Colon.
C T—Connective Tissue.
EPI—Epithelial Tissue.
F T—Fat Tissue.
GIZ—Gizzard
HYP—Hypodermal Tissue.
ILL—Ileum.
INT—Intima.
L M—Longitudinal Muscles.
LU—Lumen.
MI—Mid-intestine.
M T—Malpighian Tubules.
NI—Nidus.
OES—Oesophagus.
O V—Oesophageal Valve.
P V—Pyloric Valve.
REC—Rectum.

EXPLANATION OF PLATES

Plate I

Fig. 1. Cross section through the gizzard.
Fig. 2. Cross section through the oesophagus.
Fig. 3. Dorsal view showing the gross dissection of the alimentary tract.

Plate II

Fig. 4. Gross drawing of one of the finger-like projections of the oesophageal valve.
Fig. 5. Longitudinal section through the oesophageal valve, showing the posterior portion of the oesophagus, the gizzard, and the anterior portion of the mid-intestine.

Plate III

Fig. 6. Cross section through a malpighian tubule just prior to first entrance into the alimentary tract at the pyloric valve, showing the surrounding envelope of connective tissue.
Fig. 7. Cross section through a malpighian tubule in the body cavity.
Fig. 8. Longitudinal section through the pyloric valve, showing the posterior portion of the mid-intestine, the entrance of the malpighian tubules into the lumen of the alimentary tract, and the anterior portion of the ileum.
Fig. 9. Cross section through the ileum immediately posterior to the second entrance of the malpighian tubules into the alimentary tract, showing the tubules beneath the connective tissue.

Plate IV

Fig. 10. Cross section through the anterior portion of the rectum, showing the surrounding envelope of malpighian tubules immediately beneath the connective tissue.
Fig. 11. Cross section through the posterior portion of the rectum.

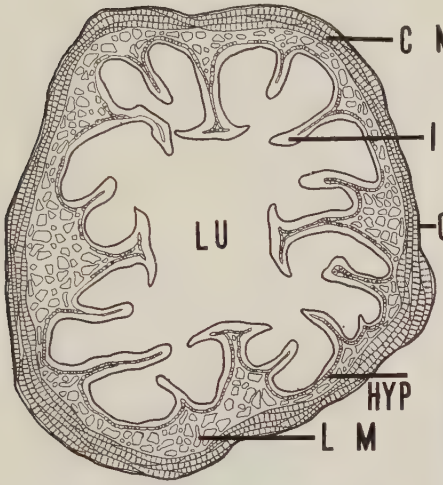

FIG 1

FIG 2

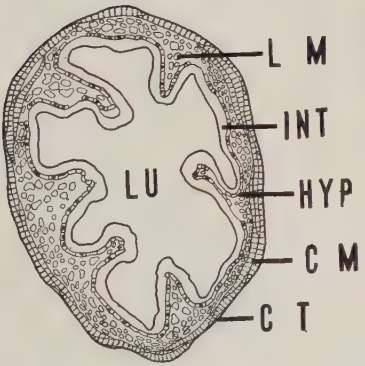

FIG 3

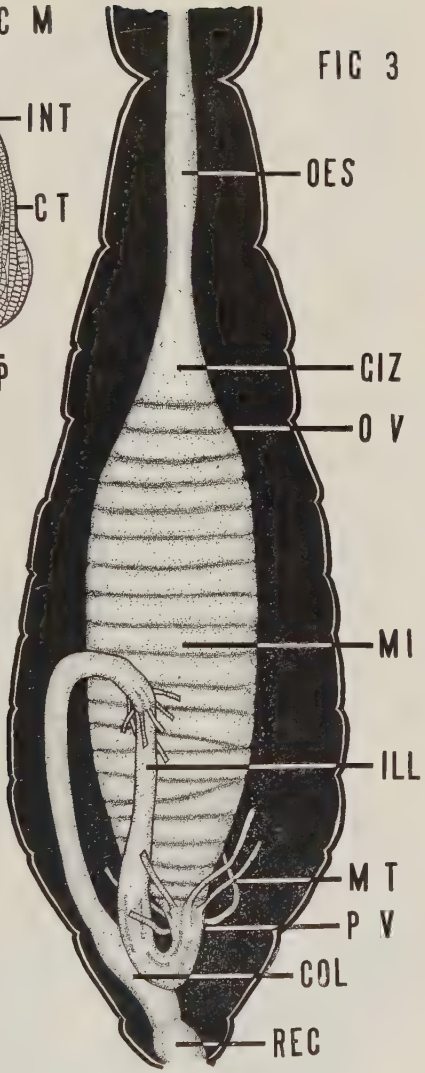

FIG 4

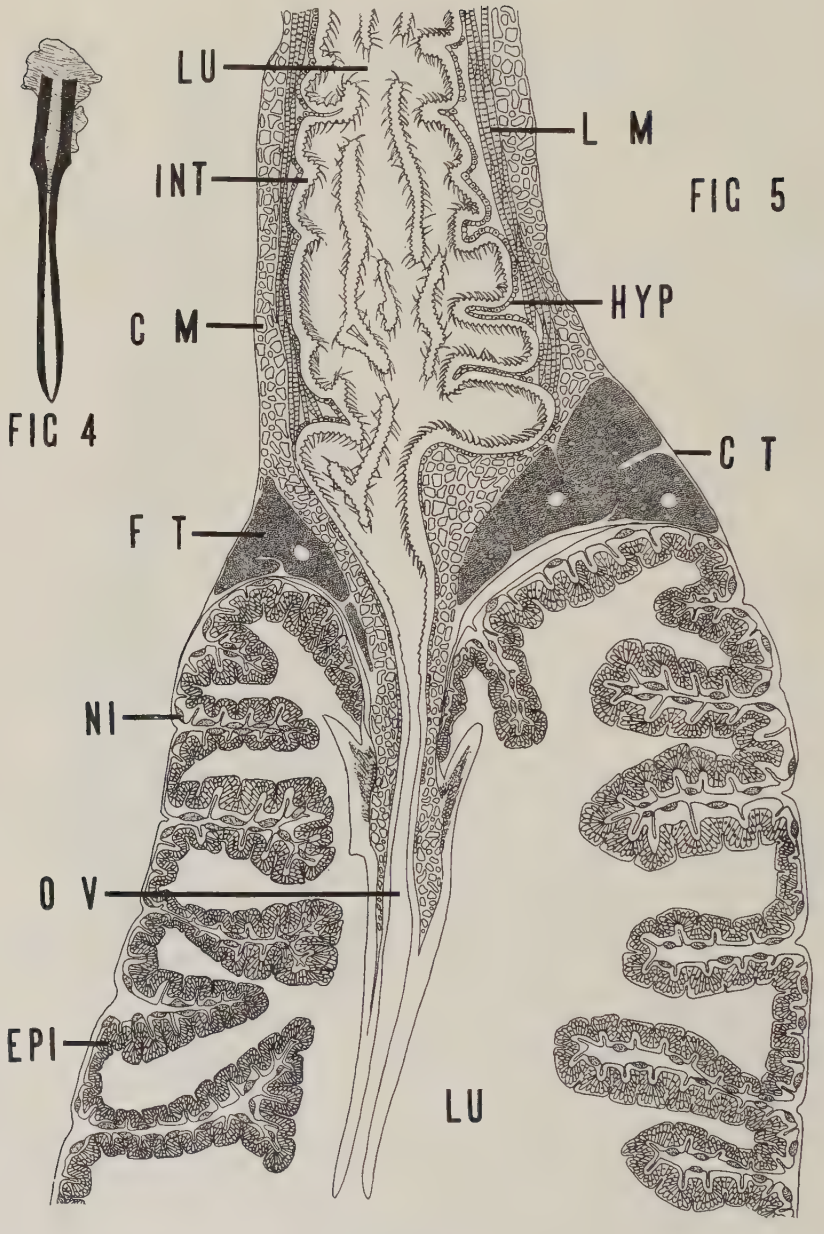

FIG 5

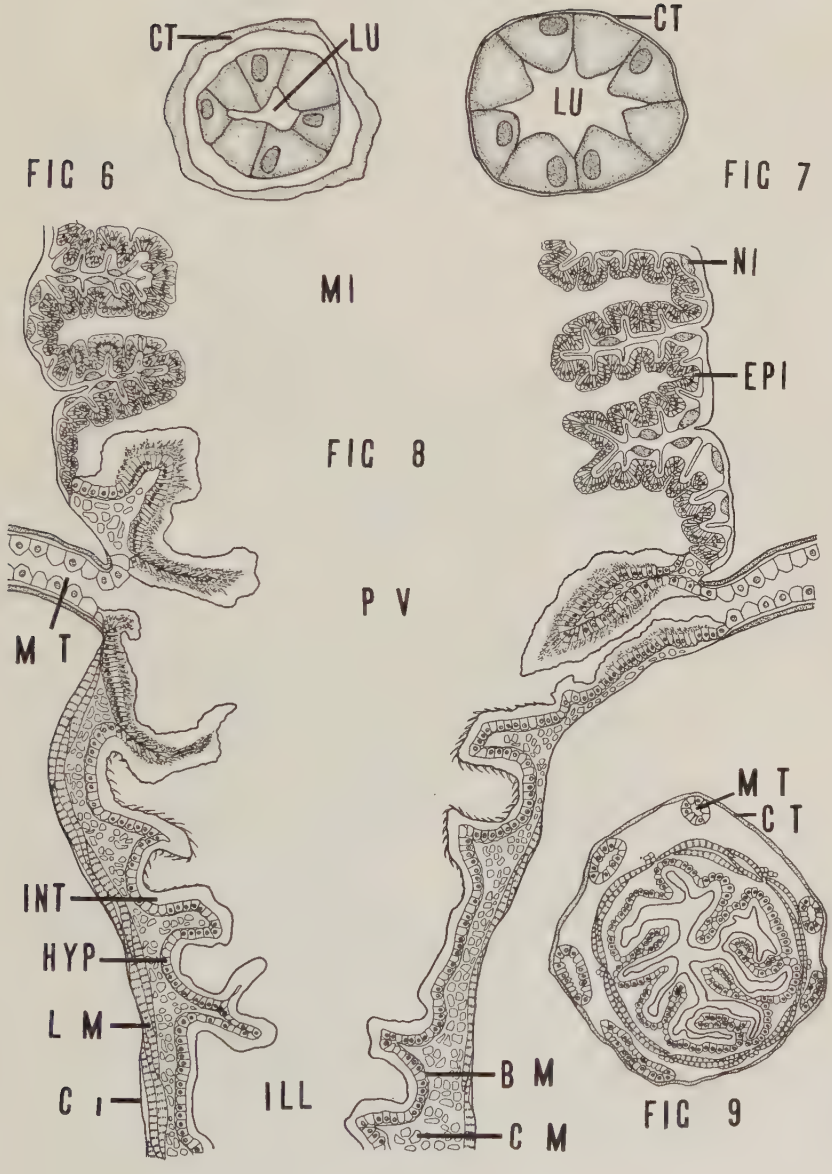
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FIG 6
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FIG 9

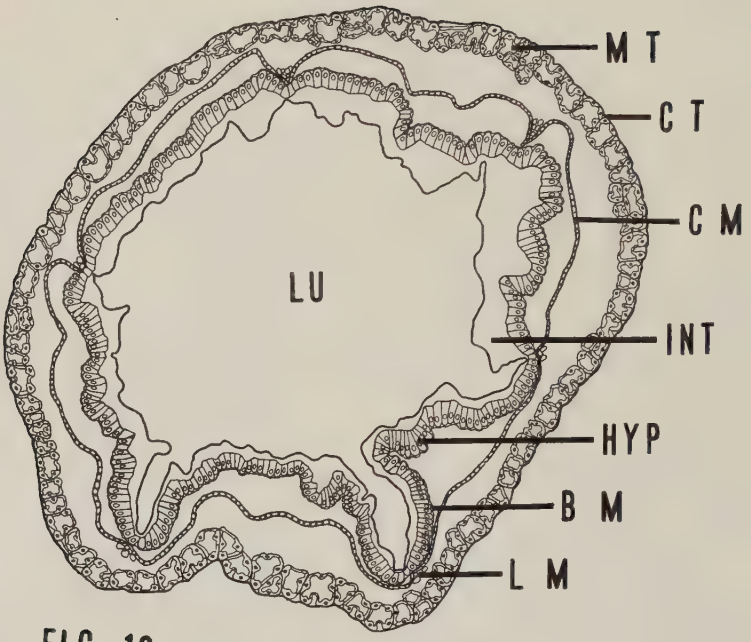

FIG 10

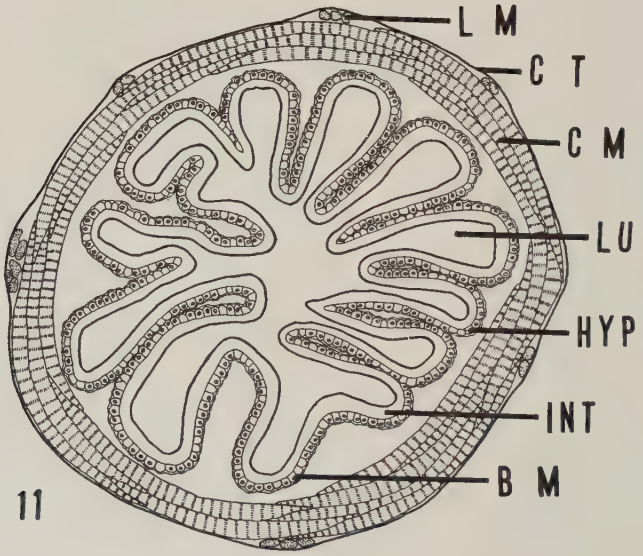

FIG 11

SOME NEW GENERA OF LEAFHOPPERS RELATED TO THAMNOTETTIX

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In a recent paper Dr. E. D. Ball[1] has described several new genera of species formerly included in *Thamnotettix*. Others from the same group are described herewith, especially genera containing grass feeding species. A synopsis of each of the genera described below is now in manuscript form and will appear separately together with illustrations of the species characters of each genus.

Genus **Ballana** DeLong, nov.

Resembling *Gloridonus* Ball but more robust, with broader head and usually larger in size. Vertex usually bluntly, sometimes rather sharply angled, margin usually thick. Venation similar to *Gloridonus*, elytra usually broad, apical cells short. Male oedagus long and slender one side bearing teeth, the other side without. Male ninth segment with two pairs of dorsal spines which may be single or bifurcate.

Type of genus *Thamnotettix vetula* Ball.

This genus comprises the *atridorsum* series including the vetula, vespertina, vivata and visalia group described by Ball and since he described most of the species now named in this genus I take pleasure in dedicating it to him. All of these are western species and occur on *Chrysothamnus*, other shrubs and some herbaceous plants. Their habitat is the desert areas of the western United States.

Subgenus **Viriosana** DeLong, nov.

Closely related to *Ballana* and with similar genital structures but with vertex very blunt and rounded. Vertex only slightly longer at middle than next the eyes, margin thick and rounded to front, broadly rounded between eyes.

Type of subgenus *viriosa* Ball.

Subgenus **Laterana** DeLong, nov.

Closely related to *Ballana* but larger and more robust, vertex broadly bluntly angled, apex bluntly pointed, vertex flat, margin acutely angled with front. Male ninth segment differing from *Ballana* in having a pair of spines directed inwardly, arising from the basal arm between the anterior and posterior pairs of spines as found in *Ballana*.

Type of subgenus *dissimilata* Ball.

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[1]Bul. Brook. Ent. Soc., 31: 57, April, 1936.

Genus **Elymana** DeLong, nov.

Long, slender, pointed headed species resembling *Gloridonus* Ball. Vertex sharply jointed and acutely angled with front. Elytra long and narrow. Venation as in *Thamnotettix*. Ninth segment of male long, tapering to a pointed spine like process. Oedagus long tapering to a long slender, dorsally directed process. Female segment truncate.

Type of genus *Thamnotettix inornatus* Van Duzee.

The species of this genus are closely related and are usually found in woody areas on Elymus and related grasses. They are probably closely related to certain species of the genus *Laevicephalus* DeLong.

Genus **Cyperana** DeLong, nov.

Related to *Elymana* but with vertex rounded and bluntly angled, not strongly produced, bluntly angled with face margin thick. Usually some shade of green or yellow with a black band or a row of black spots on margin of vertex. Elytra long and narrow, venation of *Thamnotettix* type.

Type of genus *Thamnotettix melanogaster* Prov.

The species belonging to this genus occur in the fresh water marsh on sedges of the Cyperus group. Most of these occur in the eastern United States.

Genus **Graminella** DeLong, nov.

Resembling and apparently intermediate between *Laevicephalus* on the one hand and *Deltocephalus* on the other. Vertex usually produced but bluntly angled, margin thick venation simple but with second anteapical cell long and constricted at middle. This causes the second apical cell to be very short comparatively.

Type of genus *Thamnotettix aureovittatus* Sanders and DeLong.

The species of this genus are all grass feeders so far as is known and are common on the fresh and salt water marshes of the eastern United States, occurring especially on the grasses of the Spartina association. Certain species also occur on the wet and dry prairies of Illinois and other middle western states.

Genus **Calana** DeLong, nov.

Allied to *Graminella* but differing by having a more pointed head and with a rather definite margin on vertex which is accentuated by a marginal line. Vertex angularly produced, length equalling basal width between eyes, almost flat, acutely angled with front. Elytra with venation as in *Graminella* with second anteapical cell rather long and constricted at middle. It differs however in having the first anteapical cell almost as long as second, narrow, with a marginal vein to costa anterior to middle. Genitalia entirely different in form from the type found in *Graminella*. In lateral view the male oedagus is broadly U-shaped and the posterior portion bears a pair of lateral processes near the apex.

Type of genus *Thamnotettix umbricatus* Ball.

Genus **Deltocephalus** Burm.

Subgenus **Unerus** DeLong, nov.

Closely related to *Deltocephalus* and with the same type of genital structures but differing by having one cross vein between the two sectors instead of two as found in *Deltocephalus*. Vertex bluntly angled, rounded to front, without prominent margin.

Type of subgenus *Thamnotettix colonus* Uhler.

To this group also belongs *nigrifrons* Forbes. Both species are certainly closely allied to *Deltocephalus* in every way but lack one of the two cross veins which characterizes the species of that genus.

Ancient Artizans

There is available a large amount of interesting information which concerns insects and their relations to human society. Much of this information is in scientific journals and periodicals beyond the reach of the ordinary reader. Dr. Frost has gathered many of these interesting bits of information from the scientific literature and has brought them together into this very interesting volume. The presentation is of a popular nature and should appeal to the layman. The book should also be very helpful to nature lovers and to teachers of biology in high schools, and for beginning courses in entomology it will serve as excellent supplementary reading.

There are seventeen chapters which are given headings as follows: I, Introduction; II, Foragers, Wanderers, Nomads, Hunters; III, Agriculturalists; IV, Masons; V, Carpenters; VI, Spinners, Weavers, Tailors, Lace Makers; VII, Miners; VIII, Aviators; IX, Paper Makers; X, Divers; XI, Wax Workers; XII, Garbage Collectors; XIII, Musicians; XIV, Assassins; XV, Miscellaneous Artizans; XVI, Fishermen; XVII, Death, Sleep, Death Feigning, Hibernation. Numerous references are given at the end of each chapter in case the reader desires more information on a particular subject. An index is included at the end of the book. Scientific names are given at the bottom of each page on which a particular insect species is discussed.

The illustrations have been taken from the literature and many of them are not the best that may be found in some of the scientific journals. The book is well bound and printed on good paper.—R. H. Davidson.

Ancient Artizans, by Stuart Ward Frost. 295 pp. Boston, The Van Press, 1936. $3.50.

Human Biology

The author of "Genetics and the Social Order," which was reviewed in a recent number of this journal, has attacked the broader problem of human behavior with the same keen insight, clarity of presentation, and stimulating suggestions which characterized his earlier book. The volume opens with several well-written chapters about the forces of the environment and their interaction with the genetic make-up of the animal. Then follow a series of chapters on cells, heredity, mutation and evolution. The final two chapters deal with human behavior in general, and racial and social behavior in particular. The author adheres scrupulously to the scientific method, rejecting all guess-work, wishful thinking and unfounded opinions, holding only to that which is known or may reasonably be assumed on scientific grounds. As in his previous book, he attacks eugenic propaganda, but the student of human genetics will be forced to agree with him in most of his conclusions. The book is highly recommended to biologist and layman alike.—L. H. S.

Biology and Human Behavior, by Mark Graubard. 413 pp. New York, Tomorrow Publishers (303 Fourth Ave.), 1936. $2.50.

SEVEN NEW SPECIES OF THE GENUS APHALARA (HOMOPTERA: CHERMIDAE)

JOHN S. CALDWELL
Ohio State University

Aphalara constricta n. sp.

Length to tip of forewing 3.–4. mm.; forewing 2.–3. mm.

Color: Greenish yellow.

Vertex two-thirds as broad as long, scarcely wider than pronotum; notch at end of median line slight, rounded. Foveal impressions very broad, shallow. Antennae as long as width of head.

Thorax robust, strongly arched. Forewing two and half times as long as broad. Veins yellow, conspicuously raised; membrane hyaline, coriacious. Cu_1 scarcely arched.

Genitalia: Male genital plate much elongated. Proctiger shorter than forceps; lobes longer than plate, caudal two-thirds with margins subparallel in lateral apsect, apices rounded. Forceps long, slightly broader at apex than base; margins sinuate in lateral aspect; apices very broadly rounded. Oedeagus with anteriorly directed hook apically.

Female genitalia as long as rest of abdomen; both ventral and dorsal valves styliform for caudal half; dorsal valve more so than ventral. Dorsum of caudal half of dorsal valve finely serrate.

Male holotype, female allotype, and two female paratypes from Hereford, Ariz., July 28, 1907, with no collector label are in the H. Osborn collection, Ohio State University. One female paratype from American Falls, Ida., 6–25–30, and one female paratype from Murtauch, Ida., 6–21–30, both collected by D. M. DeLong are in the DeLong collection at Ohio State University.

Aphalara osborni n. sp.

Length to tip of forewing 2.75–3. mm.; forewing 2.–2.5 mm.

Color: Pale yellow to pale green; thorax marked with yellow.

Head usually strongly deflexed, a little over twice as broad as long. Vertex two-thirds as long as broad; foveal impressions small, shallow. Antennae longer than width of head.

General build much less robust than *constricta*. Thorax strongly arched, not unusually broad. Wings resembling *constricta* but differing as follows: more yellowish, less rugose; Cu_1 strongly arched, shorter.

Genitalia: Male genital plate very large. Proctiger as long as forceps; lobes as long as plate, widely attached at base; ventral margins narrowed from ventral hook to acute apices. Forceps broad at bases and apices; cephalic margins greatly concave midlength; caudal margins straight for basal half thence rounded cephalad to broad apices.

Female genital segment about as long as rest of abdomen. Dorsum of dorsal valve straight to within four-fifths of apex thence narrowed ventrally to a blunt apex. Ventral valve narrowed on dorsal margins for apical half.

Male holotype, female allotype, and two female paratypes collected by Dr. H. Osborn at Pueblo, Colo. date unknown, are in the H. Osborn collection. One male and two female paratypes collected by Dr. D. M. DeLong at Sardine Canyon, Ut., 7–22–33, are in the DeLong collection.

The writer takes great pleasure in naming this species in honor of Dr. Herbert Osborn who has made it possible for him to work on the chermids.

Aphalara delongi n. sp.

Length to tip of forewing 3.–3.5 mm.; forewing 2.5–3 mm.

Color: Greenish yellow marked with straw yellow on thorax.

Head wider than pronotum, at least as wide as broadest part of thorax, two and a half times as broad as long. Vertex two-thirds as long as broad; notch at end of median line sharp, deep. Antennae one and a half times as long as width of head.

Thorax scarcely arched. Forewings two and a half times as long as broad, rugose, hyaline; veins yellow, raised; cell formed by long branch of cubitus, long, broad.

Genitalia: Male genital plate extremely large. Proctiger short; lobes shorter than plate, with acutely pointed apices. Forceps longer than proctiger, of equal width to apices; anterior-mesal process prominent, not concealed by forceps in lateral aspect.

Female genital segment shorter than rest of abdomen. Middle third of dorsal valve elevated. Ventral valve with caudal third of dorsal margins narrowed.

Male holotype from Northeast, Pa., 6–17–19, collected by D. M. DeLong. Female allotype from Charter Oak, Pa., 7–11–17, collected by H. B. Kirk. Twenty-one male and female paratypes from Charter Oak, Speechville, Harrisburg, Conewago, and Foxburg, Pa., collected during June and July by J. G. Sanders, H. B. Kirk, and D. M. DeLong. All types are in the DeLong collection.

The writer takes great pleasure in naming this species in honor of his teacher and advisor, Dr. Dwight M. DeLong.

Aphalara furcata n. sp.

Length to tip of forewing 2.5–3. mm.; forewing 2.–2.5 mm.

Color: Vertex yellow; thorax yellowish green; abdomen green.

Head over twice as broad as long, as wide as thorax. Vertex two-thirds as long as broad; notch at end of median line shallow. Foveal impressions rather large, deep. Eyes very prominent. Antennae one and a half times as long as width of head.

Thorax not broad, moderatley arched. Forewings slightly over twice as long as broad; longer in female than male. Cu_1 scarcely arched forming almost triangular marginal cell.

Genitalia: Male genital plate as long as broad in lateral aspect. Lobes of procitger longer than plate, narrow for full length; apices broadly rounded. Forceps longer than proctiger; basal half straight, narrow; apical half curved cephalad, enlarged on cephalic margin.

Female genital segment shorter than rest of abdomen. Ventral valve much shorter than dorsal, narrow; apex with shallow notch.

Holotype male from Northeast, Pa., 6–17–19, collected by D. M. DeLong. Allotype female collected by J. G. Sanders at Allenhurst, Pa., 6–20–19. Fifty male and female paratypes collected in June and July by D. M. DeLong, J. G. Sanders, and J. N. Knull, at North Bloomfield, Duncannon, Harrisburg, Pt. Royal, Charter Oak, Allenhurst, and Speechville, Pa., and Battle Pt., Va. These are in the DeLong collection. One female paratype is in the H. Osborn collection from Sault Ste. Marie, Ontario, 1904, no collector label present.

Aphalara bifida n. sp.

Length to tip of forewing 2.5–2.75 mm.; forewing 2. mm.

Color: Vertex yellow; thorax and abdomen greenish yellow; thorax with four more or less distinct longitudinal green stripes.

Resembling *furcata* but differing as follows: Vertex proportionally shorter; notch at end of median line shallower; foveal impressions less distinct. General build less robust. Thorax less arched. Forewings very flaveous; cubital cell longer, narrower. Dorsal valve of female genital segment shorter, straighter. Ventral valve with deeper notch at apex. Whole genital segment more thickly beset with small setae.

Male unknown.

Female holotype and two female paratypes from Miami, Fla., 1–24–34, collected by the author are in his collection.

Aphalara hebecephala n. sp.

Length to tip of forewing 3. mm.; forewing 2.5 mm.

Color: Appearing pale green; praescutum straw yellow.

Head three times as broad as long, much wider than pronotum. Vertex over one-third as long as broad, scarcely produced beyond cephalic margins of eyes; foveal impressions large, shallow. Eyes very prominent. The antennae are missing on all specimens.

Thorax scarcely arched. Forewings scarcely twice as long as broad; Cu_1 greatly arched.

Genitalia: Male genital plate small. Proctiger long; lobes large, much longer than plate. Forceps short, bifed; basal portion short, straight; caudal lobe long, acuminate; anterior lobe short, straight, directed dorsad. Oedeagus with abrupt knob-like apex; small hook apically on anterior margin.

Female genitalia with dorsal valve shorter than ventral; apex bifed.

Described from one male and two females collected by C. J. Drake, 6–5–17, Cranberry Lake, N. Y. Male holotype, female allotype, and female paratype are in the H. Osborn collection.

Aphalara sinuata n. sp.

Length to tip of forewing 2.5 mm.; forewing 2. mm.

Color: Solid greenish yellow.

Head less than twice as broad as long, as wide as thorax. Vertex flat; notch at end of median line shallow, rounded. Antennae missing.

Thorax strongly arched, not broad. Forewing over two and a half times as long as broad, transparent. Cell formed by long branch of cubitus broad.

Genitalia: Male genital plate very large, much longer than broad in lateral aspect. Proctiger short; lobes shorter than genital plate, margins sinuate, apical third gently narrowed. Forceps with basal two-thirds bulging caudad, thence constricted with apical third bulging again roundedly to caudal apical point; cephalic margins gently concave, rounded apically to the caudal apical point in lateral aspect.

Female unknown.

Described from one male collected by G. I. Reeve at Tower City, N. Dakota. Male holotype is in the H. Osborn collection.

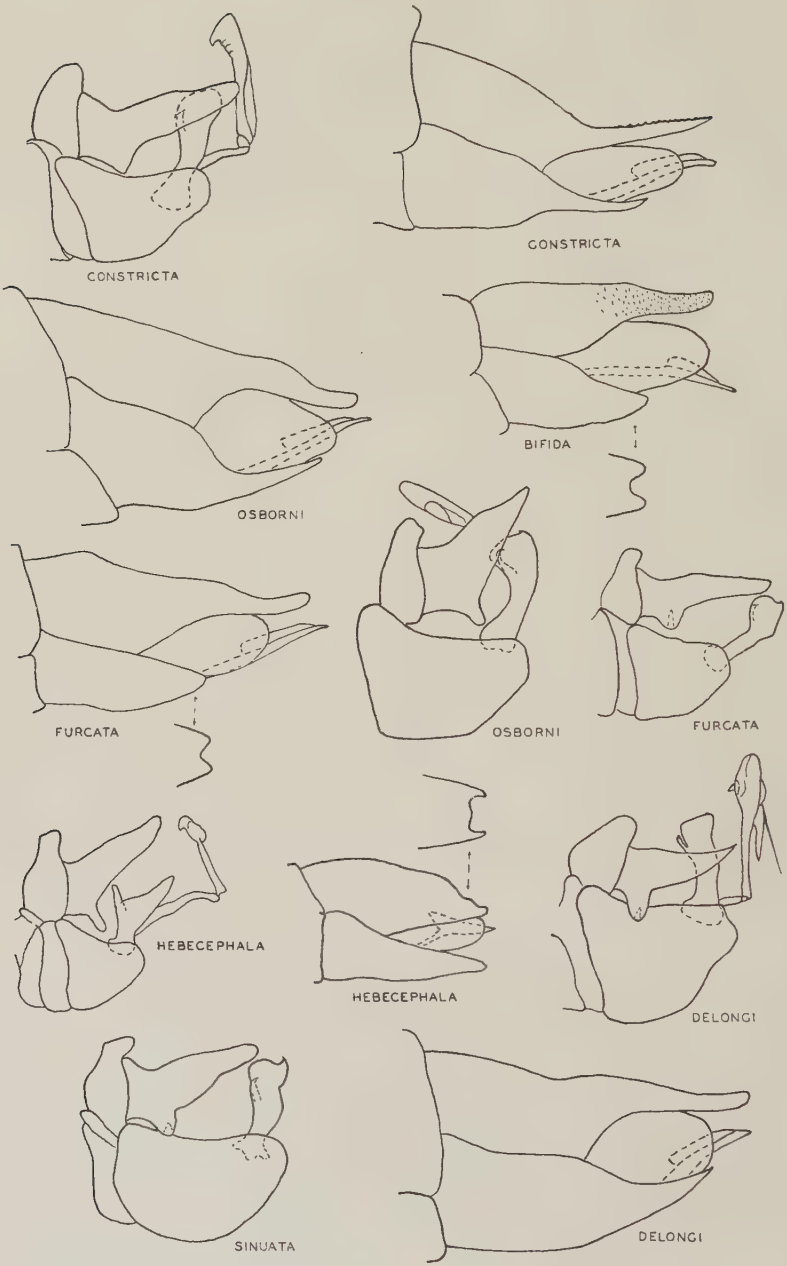


FIG. 1. Lateral View of Male and Female Genitalia.

FURTHER STUDIES OF THE GENUS EMPOASCA.[1] (HOMOPTERA, CICADELLIDAE.)

Part IV

Eleven New Species of *Empoasca* from the United States

DWIGHT M. DeLONG
AND
RALPH H. DAVIDSON,
Ohio State University

Empoasca gelbata n. sp.

Resembling *obtusa* in general appearance but with distinct genitalia. Length, 4 mm.

Vertex broadly rounded, slightly produced at middle, almost parallel margined.

Color: Dull yellowish to greenish yellow, tinged with brown.

Genitalia: Female last ventral segment strongly, roundedly, produced, becoming somewhat pointed at apex. Male plates rather short, gradually tapering to blunt apices. Lateral processes of pygofers in ventral view slightly narrowed near apex, the inner margin curving outwardly at apex. In lateral view the processes are notched dorsally near apex, and concavely excavated ventrally beyond this notch. Spine of ninth segment sickle-shaped, the apical half narrower, with apex extending almost ventrally.

Described from a male specimen collected at Fish Lake, Wisconsin, August 15, 1924; and four male and four female specimens collected October 11, 1919, at Ames, Iowa, and one female collected at Madison, Wisconsin, July 29, 1917. The specimens from Ames, Iowa and Madison, Wisconsin, were collected by Dr. E. D. Ball. Male holotype from Fish Lake, Wisconsin, and female paratypes from Ames, Iowa, and Madison, Wisconsin, in DeLong collection. Female allotype and male and female paratypes from Ames, Iowa, in Ball collection.

Empoasca gleditsia n. sp.

In form and general appearance this species resembles *pergandei*, but with distinct genitalia. Length 3.5 mm.

Vertex broadly rounded, scarcely produced, parallel margined, twice as wide between eyes as median length.

Color: Green tinged with yellow. Elytra subhyaline, veins paler, a black spot just anterior to each posterior cross vein.

Genitalia: Female last ventral segment roundedly produced, bearing a rather deep narrow notch at apex which is rounded at base. Male plates long and rather narrow. Lateral processes of the pygofer in lat-

[1]Previous studies of this group are summarized in Ohio Journal of Science 35: 29, January, 1936.

eral view enlarged and bent upward just before apical portion which is slender and curved slightly caudally. In lateral view these processes are narrowed and curved inwardly at apex. Spine of ninth segment short and broad with an anterior, ventrally pointed projection.

Described from a series of nine male and female specimens collected at Twin Falls, Idaho, June 23, 1932, from Globe Locust. Male holotype, female allotype and male and female paratypes in DeLong collection.

Empoasca chelata n. sp.

Resembling *bifurcata* in general appearance but with distinct genitalia. Length 3 mm.

Vertex produced and bluntly angled, one-fourth wider between eyes than length at middle.

Color: Bright green tinged with orange.

Genitalia: Female last ventral segment roundedly produced. Male plates long and tapered to blunt apices. Lateral processes of pygofers bifurcate at apex forming a chela. Spines of ninth segment short and broad, broadly concavely rounded on anterior margin forming a ventrally, anteriorly directed spine.

Described from two specimens collected at Okolona, Mississippi, June 14, 1934, from *Crateagus* by Mr. D. W. Grimes. Male holotype, female allotype, in DeLong collection.

Empoasca setata n. sp.

In form and general appearance resembling *Forcipata fieberi*. Closely related to *erigeron* but with distinct genitalia. Length 3.5 mm.

Vertex strongly produced, bluntly angled, one-third wider between eyes than length at middle.

Color: Yellow tinged with orange, anterior margin of pronotum with three pale spots one at middle and one behind either eye.

Genitalia: Male plates long, concavely curving on outer margin, apices broadly curved and slightly enlarged. Lateral processes of pygofers in ventral view tapering to pointed apices, usually crossed before apex. In lateral view they taper to a pointed apex which is slightly deflected. Spine of ninth segment short and broad, deeply notched anteriorly to produce a long narrow apical portion directed anteriorly.

Described from a single male specimen from Santa Fe, Mexico, collected in October, 1898. Male holotype in DeLong collection.

Empoasca rubrata n. sp.

Form and general appearance of *aureoviridis* but with distinct genitalia. Length 4.5–5 mm.

Vertex broadly rounded, more than twice as broad as length at middle.

Color: Brown, tinged with dull reddish. Elytra smoky, veins brownish. Vertex, pronotum and scutellum sometimes entirely reddish.

Genitalia: Last ventral segment of female strongly roundedly produced, slightly broadly notched at apex. Male plates narrowed to blunt

apices. Lateral processes of pygofers in ventral view curving inwardly on apical half, enlarged by inward bulge just before rapidly narrowed, pointed apex. Slightly indented on outer margin opposite bulge. In lateral view the lateral processes are concavely excavated on ventral portion of apex which is very narrow and sharply pointed. Spine of ninth segment modified sickle-shaped, apical half narrow.

Described from a series of one male and four female specimens collected at Fish Lake, Utah, September 2, 1930, by the senior author; a male and two female specimens from the same locality collected August 16, 1929, by Dr. R. H. Beamer, and a male from Toas County, New Mexico, collected August 20, 1927, by Dr. R. H. Beamer; two male specimens collected at an altitude of 8,000 feet in Rincon Mountains, Arizona, July 5, 1916, by A. A. Nichol; one male from Newaygo, Canada, collected July 30, 1929; and one male from Phillips, Wisconsin, collected July 18, 1932. All except the specimens from Fish Lake collected by the senior author are in the University of Kansas collection. The following specimens are in the collection of Dr. E. D. Ball: One male from Little Beaver, Colorado, July 19, 1898, and one male and two females from Ames, Iowa, collected July 12, 1898. The Herbert Osborn collection has a series of males and females from Cranberry Lake, New York, collected in August, 1920.

Male holotype, female allotype, and male and female paratypes from Fish Lake, Utah, deposited in the DeLong collection. Male and female paratypes in Herbert Osborn collection; Snow collection, University of Kansas; and Ball collection.

Empoasca jacinta n. sp.

In form resembling *obtusa* but with distinct genitalia. Length 4 mm.

Vertex broadly rounded, scarcely produced, more than twice as wide as long.

Color: Green tinged with yellow.

Genitalia: Female last ventral segment strongly roundedly produced. Male plates long, rather uniform in width, rounded at apex. Lateral processes of pygofers in lateral view with apex narrowed and tapering to pointed tip. In ventral view they are very slender, enlarged near apex and curving outwardly, the inner margin concavely rounding, the apex pointed and directed inwardly. Spine of ninth segment sickle-shaped.

Described from a series of twelve male and female specimens collected at San Jacinto Mountains, California, July 15, 1930, by Mr. D. G. Hall. Male holotype, female allotype and male and female paratypes in Snow Entomological Collection, University of Kansas. Male and female paratype in the DeLong collection.

Empoasca ziona n. sp.

Resembling *obtusa* in general appearance but with distinct genitalia. Length 3.5 mm.

Vertex broadly rounded, scarcely produced, twice as wide as long.

Color: Dull green tinged with brown. Anterior margin of pronotum with white spots.

Genitalia: Female last ventral segment slightly, roundingly produced. Male plates long, tapered to blunt apices. Lateral processes of pygofers in ventral view long, tapering rather abruptly, constricted and curved inwardly just before apex. Spine of ninth segment long, strongly sickle-shaped, gradually tapered to sharp pointed apex.

Described from a pair of specimens collected at Zion National Park, Utah, August 12, 1929, by Paul W. Oman; and a series of twenty-eight male and female specimens from San Jacinto Mountains, California, collected in October, 1929, by D. G. Hall. Male holotype, female allotype, and male and female paratypes in Snow Entomological Collection, University of Kansas. Male and female paratypes in the DeLong collection.

Empoasca apata n. sp.

Resembling *atrolabes* in general appearance but with distinct genitalia. Length 3.7 mm.

Head narrower than pronotum, almost parallel margined.

Color: Dull green tinged with yellow. Elytra with claval suture pale, a large black spot anterior to last cross vein. Face black.

Genitalia: Male plates rather long and narrow. Lateral processes of pygofers long with rather slender apices concave on inner margin. The outer margin is produced and curved inwardly forming pointed tips. In lateral view the apex is concavely narrowed on ventral margin to sharp pointed tip. Spine on ninth segment rather short, apical half narrower, curved caudally and pointed at apex.

Described from two male specimens, one collected at Logan Canyon, Utah, July 24, 1930, by the senior author and one at Dixie, Oregon, July 8, 1931, by Dr. R. H. Beamer. Male holotype (Utah) in DeLong collection. Paratype male in Snow collection, University of Kansas.

Empoasca grosata n. sp.

Resembling *aureoviridis* in form and general appearance but with distinct genitalia. Length 5 mm.

Vertex broadly rounded, parallel margined, three times as wide as length at middle.

Color: Golden yellow tinged with brown.

Genitalia: Male plates long, tapering to blunt apices. Lateral processes of the pygofers in lateral view appearing distinctly notched both dorsally and ventrally so as to form a curving apex which is narrowed and sharply pointed. In ventral view they are enlarged near apex by a bulge on outer margin, then tapered to pointed apices. Spine of ninth segment sickle-shaped, the pointed apex extending farther anteriorly than base.

Described from a male specimen collected at Redfish Lake, Idaho, August 3, 1930, by the senior author; one male from Cedar City, Utah, collected August 13, 1929, by Dr. R. H. Beamer, and one male from Manitou, Colorado, collected by E. S. Tucker at an altitude of 6,629 feet.

Male holotype in DeLong collection. Male paratypes in Snow collection, University of Kansas.

Empoasca confusa n. sp.

In form resembling *alboneura* but apparently more closely related to *obtusa* group. Length 3 mm.

Vertex bluntly angled and slightly produced, about twice as wide between eyes as length at middle.

Color: Dull green, mottled with white. The vertex has three longitudinal whitish areas, the pronotum a median longitudinal whitish area, and behind each eye is a large blotch of white. Scutellum with a large, median, longitudinal white area. Elytra smoky, veins paler.

Genitalia: Male plates long, almost uniform in width, apices bluntly rounded. Lateral processes of pygofers in ventral view somewhat vermiculate, apices converging, rapidly narrowed on outer margin to pointed tips. In lateral view they are enlarged just before a rather slender apical portion. Spine of ninth segment short, broad, concave on anterior margin, forming a short thick tooth directed anteriorly.

Described from a single male specimen collected at Burns, Oregon, August 3, 1927. Holotype male in DeLong collection.

Empoasca carsona n. sp.

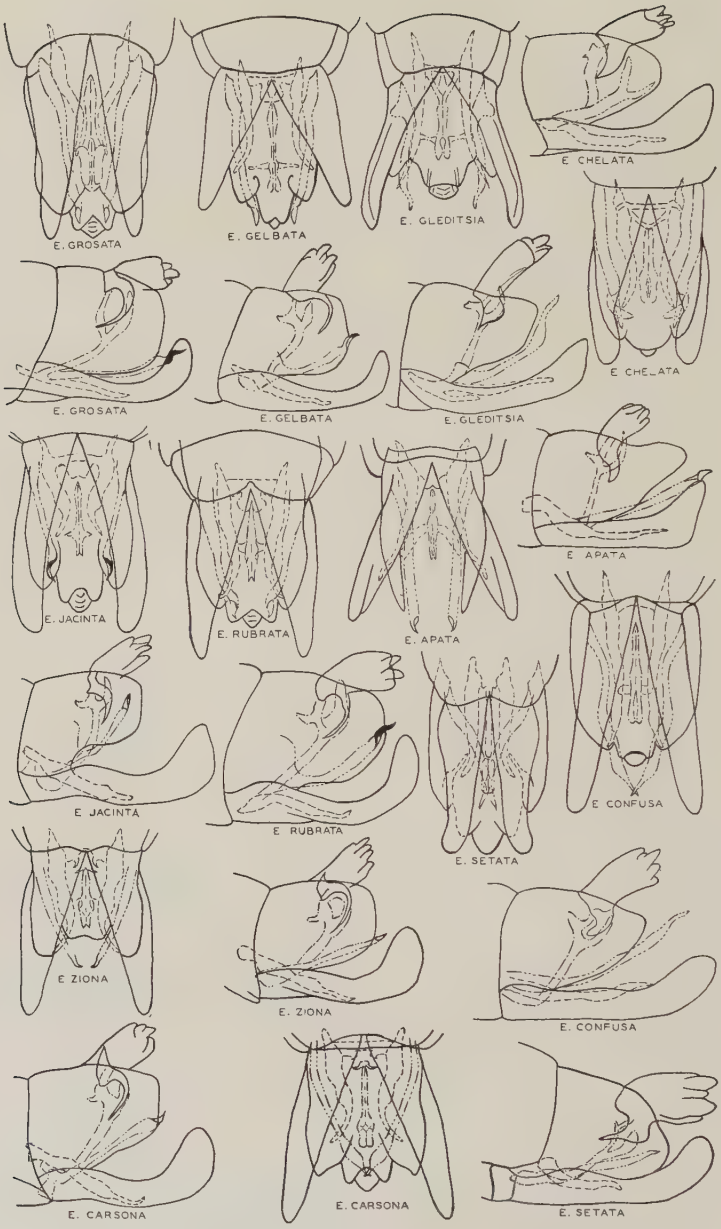
Resembling *obtusa* in form and general appearance but with distinct genitalia. Length 4–5 mm.

Vertex broadly rounded, slightly produced, twice as wide between eyes as length at middle.

Color: Green, tinged with yellow, three conspicuous white spots on vertex and three on pronotum. Elytra greenish subhyaline.

Genitalia: Female last ventral segment strongly produced and roundedly angled. Male plates rather long and narrow, tapered to blunt apices. Lateral processes of pygofers enlarged just before short and very narrow apices. In lateral view the dorsal margin of apical portion is concave. Spine of ninth segment sickle-shaped with narrowed apex directed downwardly.

Described from a series of 5 male and 28 female specimens. Four males and 21 females collected at Carson City, Nevada, August 9, 1929, by Paul W. Oman, and a male and seven female specimens collected at Maricopa County, Arizona, August 7, 1927, by Dr. R. H. Beamer. Male holotype and female allotype from Carson City, Nevada, and male and female paratypes in Snow collection, University of Kansas. Male and female paratypes in DeLong collection.



Ventral and lateral views of male genitalia showing styles, lateral processes, spine and aedagus in normal position in the genital chambers.

STUDIES IN HUMAN INHERITANCE XV

The Bimodality of the Threshold Curve for the Taste of Phenyl-thio-carbamide

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AND
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It has been shown by Snyder (1931, 1932), and Blakeslee and Salmon (1932) that the taste deficiency for phenyl-thio-carbamide (P. T. C.) is inherited as an autosomal recessive. Later Blakeslee (1932) showed that a wide variation exists in acuity of taste discrimination for the substance. He pointed out that persons who are non-tasters of the crystals can taste a saturated solution. The thresholds of those who are tasters of the crystals cover a wide range of dilutions.

It becomes important to determine whether the curve of thresholds involving both tasters and non-tasters of the crystals is actually bimodal. Do tasters and non-tasters represent one variable population, or can they be accurately separated on the basis of threshold tests?

To determine this point 584 persons were carefully tested for threshold. Of these 477 were white individuals and 107 were negroes. Of the whites, 85 were non-tasters of the crystals, while of the negroes only 8 were non-tasters.

For the thresholds tests a stock solution was made by dissolving .1 gram of P. T. C. in 99.9 cc. of distilled water. Since P. T. C. is only .26% soluble in water, this stock solution was allowed to stand overnight or was heated to 45° C. to obtain complete dissolution before it was used. From this solution dilutions were made ranging from .01% to .00001%. This range of dilutions was satisfactory for determining the thresholds of the tasters.

The solutions used for testing the non-tasters were made from a stock solution of 1.0% containing 40% alcohol, which was found to be the best solvent in addition to water. Alcohol of a strength comparable to that used in the P. T. C. solutions was used to check all non-tasting subjects, so that they would not confuse the taste of the alcohol with the taste of P. T. C.

A beaker of distilled water was given to each subject before testing so that he might rinse his mouth and become acquainted with the taste of distilled water. He was also asked to rinse his mouth immediately after noting the taste of each solution given. The solutions were placed on the back of the tongue of the subject by means of long pipettes. The weakest solutions were given first to avoid over-stimulation of those who had low thresholds. A number of trials on solutions near the threshold of the subject were made and that concentration which gave a bitter taste in half of the trials made was considered the threshold. Some subjects, however, could always discriminate between one concentration and the next strongest one.

In considering the distribution of tasters and non-tasters among the white group and among the negroes, the frequencies are obviously disproportionate, and the two racial groups must therefore be considered separately. This conclusion is based on the X^2 (Chi square) value of 6.983. The corresponding probability lies beyond the .01 limits and must be taken as indicative of uncontrollable differences between the two racial groups.

The X^2 test as used here, and also in the statements following where male and female groups are compared, takes the form:

$$X^2 = \frac{\frac{\Sigma I}{\Sigma D}\left[\Sigma I\left(\Sigma \frac{D^2}{I}\right) - \left(\Sigma D\right)^2\right]}{\Sigma I - \Sigma D}$$

Here I equals the total in any sub-group and D equals the number of non-tasters in the sub-group. The degrees of freedom for checking the probability in tables of X^2 are always one less than the number of sub-samples.

The frequencies of tasters and non-tasters among the white males and females are proportionately homogenous by the above mentioned technique. There were 251 tasters and 61 non-tasters among the males, and 141 tasters and 24 non-tasters among the females. The probability for homogenity is approximately .20. Thus no division on the basis of sex can be made.

Table I gives the frequencies of tasters and non-tasters among the white and negro groups. In following the distribution through the table it will be noted that in general the frequencies give a bi-modal grouping of thresholds in regard to concentration. One mode appears among the tasters of crystals

TABLE I

FREQUENCIES OF TASTERS AND NON-TASTERS AMONG WHITE AND NEGRO GROUPS WITH THE SCALE OF DILUTIONS OF P. T. C. GIVEN IN FRACTIONS OF 1% SOLUTION

Fraction of 1% P. T. C. Solution	Number of White Individuals	Number of Negro Individuals	
Less than .00001	13	3	
.00001	18	7	
.00002	11	2	
.00003	3	1	
.00004	4	4	
.00005	7	2	
.00006	10	4	
.00007	4	3	
.00008	11	1	
.00009	25	3	
.0001	32	7	
.0002	55	9	
.0003	46	21	
.0004	36	10	Tasters of
.0005	20	3	crystals
.0006	14	2	
.0007	22	1	
.0008	9	3	
.0009	13	5	
.001	19	2	
.002	7	2	
.003	2	1	
.004	4	2	
.005	1	0	
.006	2	0	
.007	1	1	
.008	1	0	
.009	1	0	
.01	2	2	
.02	1	0	
.03	0	1	
.04	4	0	
.05	2	0	
.06	0	0	
.07	1	0	
.08	0	0	
.09	2	0	
.1	18	1	Non-taster of
.2	20	0	crystals
.3	14	2	
.4	3	0	
.5	4	0	
.6	1	0	
.7	0	0	
.8	0	0	
.9	2	0	
1.0	12	2	

and one modal group among the non-tasters. The continuous occurrance of individuals tasting the solutions throughout the series of dilutions would suggest that there are modifying

factors that are operating on the postulated simple pair of allelomorphs that determine the major segregation of the groups in either the tests with crystals or with the P. T. C. in solution. Another interesting feature is that some individuals in the one extreme of the tabulation could detect minute traces of the substance, less than .00001 of 1%. In the other extreme some individuals listed in the class of 1% could taste only heated solutions of which the true concentration was not determined.

It should be noted in the tabulation that the intervals of dilutions are not in unit steps. This, however, need not invalidate the description of the two general groups in terms of their means and standard errors. This frequency if plotted on an arithmetic scale would give the appearance of a heavily skewed sample, but the bi-modality would not be changed. The mean threshold of the 392 taster individuals among the white group falls at .00050 with a standard error of .000064, while the mean threshold of the 85 non-tasters falls at the .33341 level in the solutions with a standard error of .002425. The mean difference is .33291 with its standard error of .03315. The ratio of this difference to its standard error is then 10.04, and the two groups as differentiated bi-modally have an exceedingly small probability of having been drawn from a homogenous population with respect to thresholds of taste.

Among the negro group the 99 tasters of crystals show a mean threshold at the .00049 level of dilution. The mean threshold for the 8 non-tasters falls at the .3437 level of dilution. These means are proportionally equivalent to the means of the white group and can be taken as indicative of the true separation of tasters and non-tasters on the basis of threshold.

The results of the above tests show that testing by solution of different concentrations of P. T. C. distinguishes tasters from non-tasters as does testing with the crystals. The variation in thresholds show that extreme differences exist between individuals. This point is entirely lost when testing only with the crystals. Although the variation in threshold seems to indicate that modifying factors are effecting the reactions of taste, the data as a whole bear out the conclusion that lack of ability to taste crystals depends on a simple recessive factor. The quantitative treatment made possible by the threshold tests bring out the reactions of taste as a variable physiological phenomenon in line with genetic behavior.

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BOOK NOTICES

Insects and Spiders

From time to time during the past several years there appeared in the National Geographic Magazine articles concerning insects and spiders, accompanied by many colored illustrations of these forms. The National Geographic Society now brings together this collection of articles and colored illustrations into one volume. In examining the book, the most striking parts of it are the excellent color plates which are indeed works of art. The photographer, artist, and others who aided in the preparation of these illustrations are to be congratulated.

The book contains a foreword by Gilbert Grosvenor and the nine chapters have the following headings: I, Exploring the Wonders of the Insect World; II, Insect Rivals of the Rainbow; III, Man's Winged Ally, the Busy Honeybee; IV, Stalking Ants, Savage and Civilized; V, Living Casks of Honey; VI, Strange Habits of Familiar Moths and Butterflies; VII, Where Our Moths and Butterflies Roam; VIII, Afield with the Spiders; IX, California Trapdoor Spider Performs Engineering Marvels. The book is well indexed. Each of the above chapters is written by an outstanding worker in the particular subject discussed. The book is well written in a style to appeal to the layman. At times Dr. Showalter becomes teleological in some of his statements. Here is an example which appears on page 19: "But the caterpillar does not eat for today alone. It foresees a morrow when, undergoing its transformation, it will have to spend days on end without a single bite of food, etc."

The reviewer feels that a more appropriate title for the book could have been selected. The printing is on excellent quality paper and the volume is well bound. This book is recommended for lovers of nature and should be a valuable asset to biology teachers.—R. H. Davidson.

Our Insect Friends and Foes and Spiders, by various authors. 252 pp., 242 figures, some colored. Washington, the National Geographic Society. $2.50.

The Orthopteran Genus Ceuthophilus

This admirable monograph sets a new standard for orthopterological publications. Although there probably remain many new species of Ceuthophilus to be described from North America, the publication will remain the standard work on the group for many years to come. The "camel crickets" or "stone crickets" have been the despair of entomologists, due partly to the lack of obvious characters for separation of the species and partly to the faulty foundation laid by early monographers. Until the appearance of the present work, few groups of insects have, in recent years, been in a more chaotic condition. Species had been described, unwittingly, from immature specimens, and the literature on the genus is cluttered with synonyms. The resultant taxonomic snarl was such that there are numerous inaccuracies in the determination of specimens by even the more expert of the students of the Orthoptera.

With genitalic characters as the basis, the author started in sixteen years ago to revise the group. Large series of specimens were amassed by his own personal efforts and an effort was made personally to examine every known specimen of Ceuthophilus in the collections of the country. As a result, 17,430 specimens are recorded in the study, in striking contrast with the 543 specimens upon which Scudder's revision was based. More than eighty North American species are treated, making the genus second only to Melanoplus among the Orthoptera, as regards number of species.

The author's treatment of the material is characterized, not only by great thoroughness and attention to detail, but also by keen taxonomic sense and good judgment. The work will be indispensable to any student who desires to recognize the species of this hitherto difficult genus. There are 26 plates with 843 figures, beautifully executed, showing outlines and structural details of the insects and 12 outline maps showing the known distribution of the species.—E. S. Thomas.

A Monographic Revision of the Genus Ceuthophilus (Orthoptera, Gryllacrididae, Rhaphidophorinae), by Theodore Huntington Hubbell. 551 pp. University of Florida Publication, Biological Science Series, Vol. 2, No. 1, February, 1936. $3.75.

Interpretative Petrology

What is interpretative petrology? It is not optical mineralogy, descriptive petrography or a classification of rocks. It is rather an attempt to bring a chemical background, with the use of minals (component parts of minerals) to the aid of interpreting igneous rocks. In addition various theories as to the origin of igneous rocks are impartially presented with their good and bad parts pointed out. The text is divided into 27 chapters. The introduction shows the likeness of Silicon and Carbon. Chapter 2 details the principles of Equilibria, bringing into the picture the phase rule and the thermal diagram of both solid solutions and eutectic series. Solid solutions and isomorphism are discussed along with the term minal. Next we find discussed polymorphism, then readjustment during crystallization and petrologic mineralogy. Chapter 7 takes up the feldspar group, 8 the pyroxene group, 9 the olivine group, 10 the amphibole and mica groups, 11 the alkali minerals, 12 the accessory minerals, 13 zoned crystals, and 14 twinned crystals. In chapter 15 the order of crystallization is taken up and the criteria of the sequence of crystallization have their weak points pointed out. Intergrowths are considered along with crystallization. The discussion of hyperfusible constituents (the dissolved gases) is followed by a discussion of the minal types of the Pacific suite, Mediterranean type of rocks, and rock types of the Atlantic suite. The crystallization of magmas is followed by a discussion of differentiation of magmas. Assimilation is concerned with the heat supply, stoping and so on, and the conclusion is that "the **place** of such activity (assimilation) may be even more important than the **age.**" The final consolidation of igneous rocks includes a discussion of the pegmatites with a table of pegmatitic minerals divided into magmatic and replacing minerals. Garnet reaction rims are followed by the petrographic provinces and comagmatic regions. The origin of igneous rocks is discussed, beginning with the source of the magmas. Then are taken up the granitic rocks, the feldspathoidal rocks, the alnoitic rocks, the norites, the anorthosites and finally the gabbros. In all are given various theories but no personal conclusions. Mode versus Norm, grain size, and a resume as to future investigations close the text. There are both author and subject indices.

This book does not attempt to take up all the igneous rocks. The rock-making minerals are considered as solid solutions and there are many diagrams to illustrate the mineral systems. The text should prove very useful for the advanced student, since it represents the bringing together of a great amount of information in a very condensed form. It fills a field which as far as we know has not been entered in this manner before. The illustrations are numerous and very clear in spite of their small size, there often being over a dozen on the same plate.—Willard Berry.

Interpretative Petrology of the Igneous Rocks, by H. L. Alling. xv+354 pp. New York, the McGraw-Hill Book Co., 1936.

Human Heredity and Social Welfare

Dr. Holmes has broadened the scope of his eugenic studies which were reviewed some time ago in this journal (**The Eugenic Predicament**), and has presented in this volume a complete and well-written discussion of the whole field of human welfare as it is affected by the inheritance of genetic factors. The first half of the book consists of a clear account of the principles of heredity, culminating in a chapter on heredity in man. Then follow a series of thought-provoking chapters on genetics in crime, delinquency, and mental aberrations, the differential birth and death rates, the growth and distribution of populations, the biological effects of war, migrations, and the intermingling of races, and finally a chapter on proposed measures for race betterment. There is nothing startlingly new in the book, but it is written with the same calm, clear, dispassionate insight which characterizes all of Dr. Holmes' works, and is free from the somewhat forced rationalization which occurs in the recent works of Graubard and Muller. The reader may add much to his enjoyment and grasp of the volume by carefully answering the stimulating questions and problems which are appended to each chapter.—L. H. S.

Human Genetics and its Social Import, by S. J. Holmes. viii+414 pp. New York, the McGraw-Hill Book Co., 1936. $3.50.